MODERN INDUSTRY

BOGART and LANDON

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MODERN INDUSTRY

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MODERN INDUSTRY

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PREFACE

The authors of this text believe that an understanding of industry precedes an understanding of business, and that this holds for the business man and the student alike. Unless his grasp of the world of industry and of natural phenomena is sufficient for him to understand the actual working out of economic principles, it is useless to ask the student to discuss these principles. The business man, too, confused by the complexity of the economic organization and looking at it from the standpoint of the market place, may easily miss the fundamental purpose, organization, and functioning of modern industry.

This book is written to supply what is conceived to be a gap in our economic text books. It is intended as a background or introduction to a study of the principles of economics. *Modern Industry* is descriptive, not theoretical; it deals with industry rather than with business and therefore touches lightly the subjects of transportation, money, and marketing. It is primarily concerned with making goods, not money profits; it discusses the technological work of society, and not the pecuniary. It conceives of the world of industry as a vast going concern and attempts to describe the work which it does and the relations of the different parts to each other. It approaches the problems of industry from the functional standpoint, being concerned with activities rather than structures, with work rather than organization. Whenever possible it has emphasized the debt which modern industry owes to science.

Much of the material in this book has been used in mimeographed form in a course in Freshman economics at the University of Illinois, but this material has been thoroughly revised and rewritten. As in other institutions, many experiments have been made with the beginning course so as to make it a suitable introduction to the principles of economics, and this book may be said to represent the answer to the problem at Illinois. It is believed, however, that this volume constitutes not merely an introduction, but an independent and distinct study which may profitably be pursued for its own sake.

Acknowledgments are made to several of our colleagues at the University of Illinois who read chapters with whose subject matter they were especially familiar. Among these were A. G. Anderson, W. O. Blanchard, A. W. Coffman, G. H. Dungan, T. E. Layng, M. M. Leighton, J. H. Longwell, W. H. Rodebush, H. P. Rusk, R. W. Stark, C. L. Stewart, and A. C. Willard. Their interest and assistance have made it possible for the authors to include descriptions of technical processes with the assurance that they are free from the mistakes which otherwise must inevitably have occurred. For this service the authors are sincerely grateful. For any errors remaining, however, and for the points of view presented the authors alone should be held responsible.

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MODERN INDUSTRY

PART I

CHARACTERISTICS OF MODERN INDUSTRY

CHAPTER I

THE PROBLEM OF MODERN INDUSTRY

The struggle for existence. — The economic history of the world is a record of the ceaseless efforts of man, at first to gain a bare subsistence, and later to improve his standard of living. Struggle has been the law of existence. Every plant is engaged in a contest with other plants for the plant food and sunshine and other factors necessary for its growth; it also struggles against the unfavorable factors in its environment, such as drought or frost, etc. In like manner animals carry on a contest with each other and with their environment, disputing each morsel of food, devouring each other, changing their habitat when supplies run low. Man is not exempt from this universal law of struggle, but he no longer exterminates or eats his fellow men, nor follows his food supply through the forests. His struggle now is with nature and the forces of the physical world, from which he attempts to wrest a living.

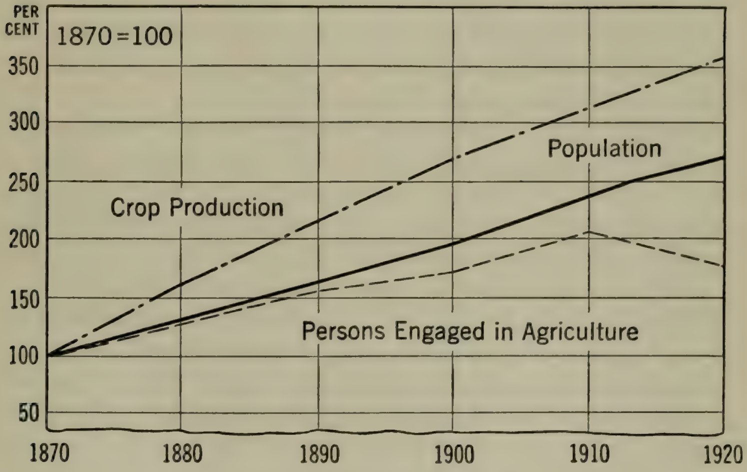
Modern industry is the present day organized effort of man to solve this perennial problem. Back of the myriad forms which our economic activities take, there is one single purpose. Stated as simply as possible, this is the effort on the part of man to obtain from his environment a suitable living. This is the economic phase of the human struggle for existence. In the solution of this problem there are two main factors to be considered; namely, (1) the size and character of the population, and (2) the abundance and quality of resources furnished by the environment. There must also be a favorable relation between these two factors in order to insure the highest well-being of the people.

Population and environment. — There are cases in which an intelligent and industrious population has been placed in the midst of an inhospitable environment and has with difficulty wrested a bare living from it. Iceland or Norway might be cited as examples. Here the difficulty lies with the physical factor. In other cases an indolent and ignorant people, located on a fertile soil in a favorable climate, is content to eke out a bare subsistence with a minimum of exertion. Some of the South Sea Islands would serve as an illustration here. In such a case the lack of progress is attributable to the human factor. If, by a happy chance, a vigorous people finds itself in a favorable environment, then the greatest economic progress may be anticipated. Such has been the case in the United States.

The quality of the population and the character of the environment are not, however, the sole determining factors. Even an industrious and intelligent people in a desirable environment might increase so rapidly as to outgrow the capacity of the environment to support it. Such has been the case in China. In order to insure the maximum well-being of a group, there must exist a favorable relation between the size of the population and the resources at its command. The history of the world shows a steady growth in the number of human beings from the beginning of written records. There has therefore tended to be a steady pressure of man upon his environment in order to obtain from it the ever larger amount of supplies rendered necessary by this growth in numbers. In explaining this process, economists have formulated two so-called laws, which must be briefly examined.

The law of population. — The first of these is the law of population; sometimes called the Malthusian Law, after its author, T. R. Malthus, who stated it in his "Essay on Population," in 1798. Malthus pointed out the possibilities of rapid reproduction among all forms of life, including man, and asserted that, unless checked, population tends to increase faster than the means of existence. The growth of population therefore leads in time to insufficient food supply, misery, sickness, vice, and death. At the time he wrote, Malthus could see no solution to this problem except by keeping down the increase in numbers. Unless man did this voluntarily, nature would maintain the necessary equilibrium by sweeping off the surplus population through wars, famines, and epidemics. In this way the population would be held down to a size which could be supported by the environment in which it lived.

The English economists of the time of Malthus, and for some time thereafter, were greatly worried by the population question, which seemed to them effectually to prevent any permanent improvement in the material well-being of the human race. They implied that our economic resources could not stand much additional strain on the side of demand. Since the supply of goods was limited, any increase of demand — that is, of population — would make conditions worse. The thing to do therefore was to keep down the population, and then the existing supplies would go round without undue stinting.



Population and Food

The curves on this chart show trends of total population, of the aggregate volume of production for the ten principal crops, and of the number of persons engaged in agriculture in the United States, 1870–1920. These indicate that the relation between population and crop production has not altered greatly since about 1880, although both have increased rapidly. The number of persons engaged in agriculture has, however, grown much more slowly, and between 1910 and 1920 showed an actual decline, but in spite of this the volume of production increased. Each person engaged in agriculture produced on the average twice as much in 1920 as he did in 1870. In other words, the population was better fed and more liberally provided with agricultural raw material with an expenditure of relatively less labor. This seeming miracle was accomplished primarily by the use of labor-saving machinery, but also by better methods of tillage, more scientific rotation of crops, and other improvements. (*Year Book,* U. S. Dept. of Agr., 1923.)

The law of diminishing returns. — Somewhat later, another principle was stated relating to the return which the environment will yield in response to man's efforts. This was that, as the application of labor and capital to the land increases, a point is finally reached beyond which an increased investment will yield a diminishing return. This may be illustrated from almost any field of activity. In working a mine the ore near the surface may be obtained at a small cost, but the deeper the mine is sunk the more it will cost to extract additional supplies. If a field of corn is cultivated a larger crop will be obtained than if it is not cultivated at all. Perhaps still more will be obtained if it is fertilized and harrowed two or three times. But a point will certainly be reached where it will not pay to add any more fertilizer or harrow again, because the yield does not increase proportionately with the effort and expense. At this point, the returns are said to diminish. More can be obtained, but only at a relatively greater cost.

If, then, the population continues steadily to increase, as the law of population says it does, and consequently, with each succeeding generation makes greater demands upon the environment for supplies of food, of minerals, of fibers for clothing, and of other things; and if, on the other hand, nature responds grudgingly to man's efforts and yields in return for his labors a proportionally diminishing return, the outlook for humanity is a dismal one. Caught between the upper millstone of increasing numbers and the lower millstone of an insufficient production of wealth, it would appear that poverty must inevitably result. And yet the twentieth century finds the peoples of the world larger in numbers and at the same time better fed, housed, and clothed than ever before in the world's history, with many of them enjoying luxuries previously unknown. How has this seeming miracle been accomplished? Who is the St. George that has routed the twin dragons and saved mankind from a terrible fate?

Modern industry solves the dilemma. — Modern industry is the agency which has thwarted, at least temporarily, the operation of these two forces. Inventions, improvements in technique, better methods of organization, and other devices whereby product can be increased or cost reduced — all these are the weapons with which this modern St. George fights the dread monsters which threaten the prosperity of mankind.

Within the modern period of history, there has been a steady growth in the numbers of the people, and within the past century a very rapid increase. Between 1815 and 1914 the white population of the world increased threefold and that of the United States increased more than twelvefold. It has been estimated that the number of persons who can be supported on the earth is about 5,200,000,000.[1] The world's population is about 1,600,000,000 today, but at the present rate of increase the limit would be reached in just a little over a century. Merely to care for the bare physical wants of these additional mouths and bodies involves the production of a vastly increased volume of goods. And if this growing population is to progress and enjoy a higher standard of living, a progressively larger and larger production must take place.

But the effort to extract from our natural resources these ever increasing supplies meets the stubborn resistance of the law of diminishing returns. It is necessary to overcome this opposition by improvements, by inventions, and by other methods of increasing the yield of land and other natural agents. This is the task of modern industry, and so successfully has it been accomplished that some writers are inclined to deny the law of diminishing returns and to substitute for it a law of increasing returns. It must never be forgotten, however, that this always lurks in the background, like Banquo's ghost at the feast, and can be exorcized only by the unremitting efforts of man to improve his methods.

The double dilemma of a growing population and of depleted natural resources must be met. It is a constant challenge to man, in which the prize is an ever richer life, and where defeat means deterioration and death. If man is to progress he must make his work count for a bigger and bigger product. Goods must be produced in greater abundance and at a lower cost. Invention and discovery and organization are the means by which this problem must be solved. New resources must be discovered, new processes invented, and new methods of organization devised. All of these mean a larger return from man's efforts, and the maintenance of a larger population on a higher plane of living.

Growth of population in the United States. — In order to show what can be accomplished by modern industry the case of the United States may be cited, for in no country has the population grown more rapidly nor, on the other hand, has the increase of material wealth been greater.

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[1] E. M. East, *Mankind at the Crossroads* (New York, 1923), p. 69.

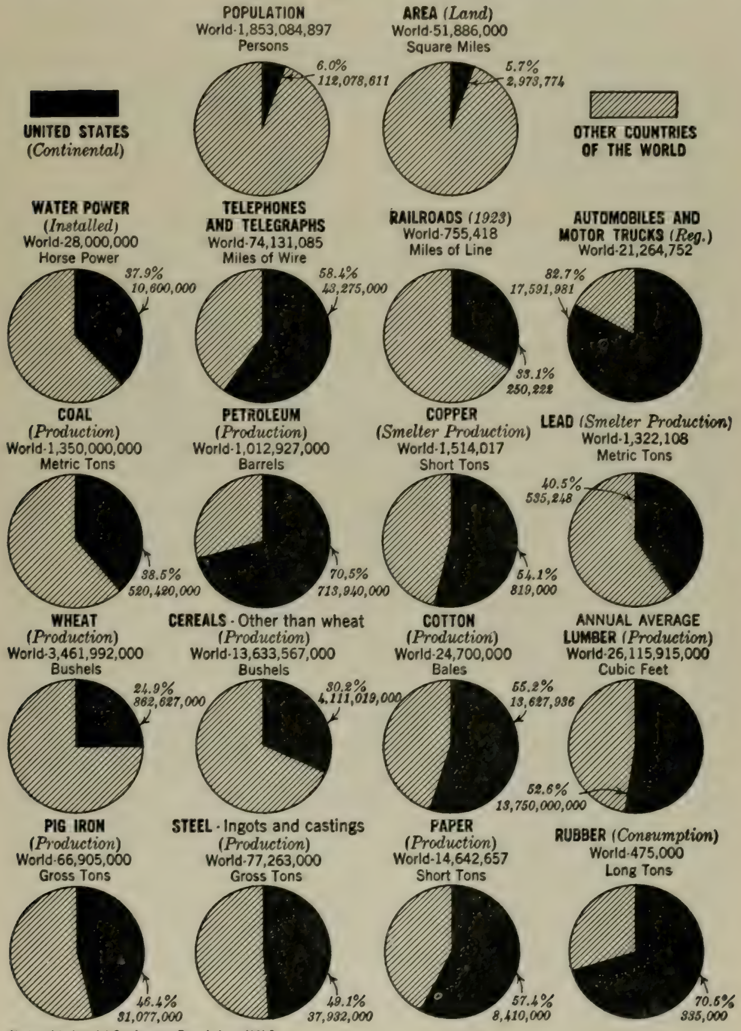
In the first place, the population has increased about thirtyfold since the first census was taken in 1790. From 3,929,214 on that date it grew to 117,135,817 on January 1, 1926. The rate of increase has been slowing down recently, but in each of the six years since 1920 we added about 1,900,000 to our population. If we maintain this rate of growth the population of the United States will reach a total of about 125,000,000 in 1930, and of 200,000,000, possibly, by 2000 A.D. Can these larger numbers enjoy the high standard of living now prevailing in the United States, or will they be forced to put up with poorer conditions? Dr. O. E. Baker, of the Federal Bureau of Agricultural Economics, has attempted to answer this question from the standpoint of food. His conclusion is " that after our arable land has increased about 100,000,000 acres, which appears likely to happen during the next 75 years, and if our yields of the crops attain those in northwestern Europe, and our diet reaches the pre-war German standard, our nation will be able to support about 300,000,000 people." But he considers it very uncertain that these conditions will be fulfilled, and, if fulfilled, they mean harder work and poorer living conditions. If the population keeps on expanding, it will be necessary to feed, clothe, house, and provide with the comforts of modern life these eighty additional millions of people. The future is faced with a very serious and practical problem.

Increase of wealth in the United States. — A glance at the past may, however, give us hope. Rapid as has been the growth of population, that of wealth has been even more so. The facts for both population and wealth since 1870, as given in the 1920 census, are presented in the following table:

Population and Wealth of the United States

Date	*Total Population*	*Total Wealth*	*Amount of Wealth per capita*
1870	38,558,371	$ 24,055,000,000	$ 624
1880	50,155,783	43,642,000,000	870
1890	62,947,714	65,037,000,000	1036
1900	75,994,575	88,517,000,000	1165
1904	81,261,519	107,104,000,000	1318
1910	91,972,266	——————	——
1912	95,538,461	186,300,000,000	1950
1920	105,710,620	——————	——
1922	109,977,758	320,804,000,000	2918
1926	117,135,817	——————	——

According to this table the per capita wealth of the people of the United States increased almost fivefold in this fifty-year period.



National Industrial Conference Board, Inc., N.Y.C.

ECONOMIC POSITION OF THE UNITED STATES AND THE WORLD IN 1924

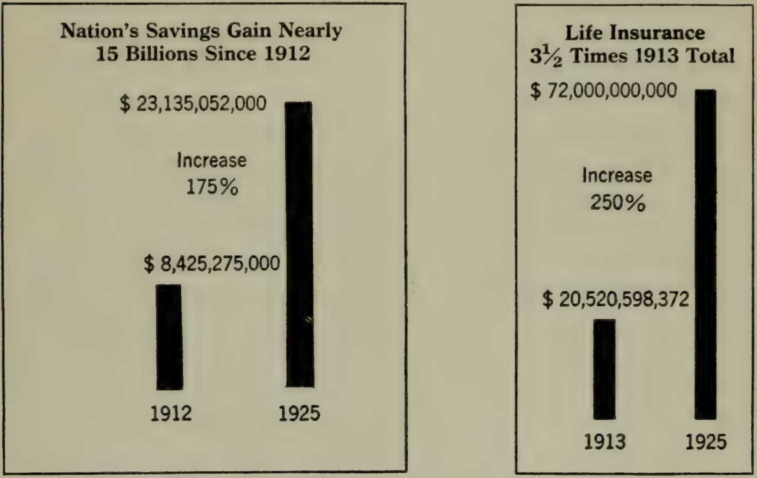
That is to say, while the population of the country less than tripled, the wealth increased thirteenfold. Even if an allowance of 50 per cent be made for the decline in the purchasing power of the dollar, the average individual would have at his command over two and one-half times as much wealth in 1922 as he had in 1870. And not only is the average American better off than was his American grandfather, but he is much wealthier than his European contemporaries. A reliable authority (The Bankers Trust Company) estimated the per capita wealth in 1923 in Great Britain at $1489, in France at $1484, and in Germany at $901.

How can this unprecedentedly rapid and vast increase in wealth be explained?

Responsible in part, no doubt, are the rich stores of natural resources to be found in the United States. But these alone do not explain the phenomenon, for the North American Indian lived in the midst of the same resources, yet never rose beyond the stage of barbarism. This growth in wealth was made possible by, and is an index of man's mastery over nature, of his discovery of her secrets, and of his ability to harness natural forces to his needs. In other words, the key to economic progress must be found in man rather than in his environment.

Raising the standard of living. — The criticism has sometimes been urged that this mere multiplication of material goods does not constitute real progress, and that, engrossed in the production of material wealth, Americans as a people have missed some of the finer products of civilization, such as leisure, and art, music, literature, and similar things. Whatever it is that constitutes the final goal of man's activities here on earth — happiness, self-realization, goodness, or other aim — it is believed that it can be realized best if the mass of men is supplied with material comforts and if the fear of starvation or poverty is removed. Whatever may be the final goal, this remains as our immediate economic aim. Plato believed that philosophers could not lead a contemplative life unless the menial work of society were performed by slaves. To-day we believe that it is possible to make and harness up iron slaves to relieve man of many of the disagreeable tasks and to increase his leisure. This is progress.

Future chapters will show in more detail the achievements in various lines of production. At this point it is sufficient to note the fact that in the United States the people have preferred to devote their increased productive capacity to multiplication of goods for the gratification of new wants and to raising the standard of comfort rather than to procure for themselves more leisure. The average American does not look forward to retiring from business; he prefers to keep on working. Thus, although there has been a slight lessening in length of the average working day, it does not nearly correspond with the growth in productive capacity.



These Figures Show Two Ways in which Americans are Making Provision for the Future

Savings. — But if increased efficiency in production has not been used to purchase leisure merely, neither has it been used to produce only goods for immediate consumption. At the same time that he has improved his standard of living the typical American has also made provision for the future. One of the most striking recent phenomena has been the growth of savings, not by a few large savers, but in innumerable small sums by the American workingmen. As an illustration, the year 1924 may be cited, in which, according to Dr. David Friday, there was a capital accumulation of 11 billion dollars. As the total income of the American people during that year amounted to about 65 billion dollars, it follows that something like one-sixth of this amount was saved. The tangible forms which these savings took were stated by Dr. Friday as follows:[2]

[2] The New Republic, March 11, 1925.

Houses and other buildings	$5,500,000,000
Railroad improvements	1,000,000,000
Public utility extensions and improvements	1,600,000,000
Additions to manufacturing plants	1,800,000,000
Roads, pavements and public improvements other than buildings	1,000,000,000
Automobiles added	1,500,000,000
Gold and currency imported	300,000,000
Foreign securities imported	1,000,000,000

"The American people have long been regarded as extravagant livers and spenders. But as one surveys these figures he cannot escape the conclusion that with all our so-called extravagance we are increasing abundantly our provision for the future."

Improvement has not been equal in all lines. — It appears then that the people of the United States during the past half century have not only increased their numbers but have expanded their wants. The double demand thus presented has been solved by increasing production. Only thus could the situation have been met. Improvements, inventions, and discoveries have resulted in a larger yield of products in every line except agriculture; here alone the increase lagged behind the growth of population. This is shown for the period 1899–1924 in the following table: [3]

Quinquennial Indexes of the Physical Volume of Production

Year	*Agriculture*	*Mining*	*Manufacture*	*Transportation*	*Population*
1899	100	100	100	100	100
1904	116	136	122	141	110
1909	118	189	155	177	121
1914	137	225	169	233	132
1919	137	257	218	291	140
1924	139	322	262	320	150

These statistics show that mining and transportation have expanded twice as rapidly as population, that manufactures have grown greatly though somewhat more slowly than the other two, and that agriculture has increased only 39 per cent in this twenty-five year period, while population increased 50 per ecnt. The explanation of these varying rates of development must be sought in the succeeding chapters.

Plan of this book. — The economic problem faced by human society has been briefly stated in the foregoing paragraphs. In the next chapter we shall study the nature of *human wants,* which furnish the motive to economic activity, because it is only by work that we can gratify them. This book is an attempt to describe some of the more important economic activities of man, and to show *how* he succeeds in gratifying his expanding desires. It is necessary first to study man's understanding and mastery of himself, and secondly to acquaint ourselves with the environment and the natural resources which are at man's disposal. The conquest of nature by man is the story of economic progress, but of this only a brief account can be given. The technique of production must also be improved if more is to be produced. Some of the more typical industries, both agricultural and manufacturing, will be studied, in order to make clear the principles underlying modern industry and the actual methods followed in the production of wealth. Before taking up these problems, however, it seems desirable to outline briefly some of the fundamental features of our present economic organization.

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[3] Taken from L. D. Edie: *Economics*, p. 42, where the complete table showing annual indexes may be found.

It is evident, in the first place, that men do not work alone, either by themselves or for themselves. Work is to-day a social process, that is, it is carried on by men in common, coöperating with each other, and working toward common ends. The whole of human society may be thought of as a great world company organized for the purpose of gratifying human wants by the production of goods and services, which they exchange with each other. Such a process manifestly involves *specialization* of each man in a particular occupation; specialization means *division of labor,* and this in turn involves the *dependence* of each worker upon others for the gratification of some, if not most, of his needs; this requires *coöperation* among the different members of the society in order to effect joint enterprises and required exchanges; and finally some sort of *organization* or coördination is necessary to give unity of purpose and action to such a huge undertaking, the several members of which might otherwise work at cross-purposes. Each of these features is so important that it will be necessary to devote to it a separate chapter.

SUGGESTIVE QUESTIONS

1. Give some examples of the economic struggle of man (a) with other men; (b) with animals or insects; (c) with nature.

2. What is meant by the optimum population in relation to a given environment?

3. In the multiplication of weeds in a garden do you have an illustration of struggle for existing food supplies?

4. Do you know of any instance where the increase of population has meant a pressure upon the environment for food?

5. Classify the methods by which the food supply of the world may be increased in the future.

6. Explain Malthus' theory of population more fully.

7. Would the rapidity with which population tends to increase lead you to think that wars among nations are inevitable?

8. Give an illustration of diminishing returns in the preparation of a lesson; in manufactures; in gardening.

9. Are any of the businesses or industries in your community in the condition of increasing or diminishing returns?

10. Do you think it possible to add 100,000,000 acres to the cultivated area of the United States? Where would this land come from?

11. Enumerate some of the inventions and discoveries that have staved off the effects of Malthus' Law of population and the law of diminishing returns during the past 150 years.

12. The following problem is given by Professor Taylor:

> "'Malthus was quite wrong when he tried to show that at life's banquet there was room for only a limited number of guests. The guests are also cooks, contributing their share of the banquet.' — Dr. Bertillon in a lecture in Paris in 1913.
>
> "Criticize this statement of Bertillon on the basis of the law of diminishing returns."

13. Explain the great difference between the per capita wealth in the United States, and that in Great Britain, France, and Germany.

14. Is it correct to say that the multiplication of material goods constitutes progress?

15. How would you define twentieth century civilization? Western civilization?

16. Why is saving economically desirable?

BIBLIOGRAPHICAL NOTE

The material contained in the first seven chapters is found scattered through books on general economics, so that the references given here will suffice for the whole of Part I.

The book which comes nearest to covering the same ground is L. C. Marshall and L. S. Lyon, *Our Economic Organization* (New York, 1921), which approaches the problem from the functional standpoint; it is designed for high schools. More advanced and more difficult, because made up of many short extracts from other writers, is L. C. Marshall, *Readings in Industrial Society* (Chicago, 1918). A brilliant study, more general than the name indicates, is Edwin Cannan, *Wealth* (London, 1914). D. H. MacGregor, *Evolution of Industry* (London, 1912) is popular, but concise and stimulating; more scholarly is J. A. Hobson, *The Evolution of Modern Capitalism* (London, 1917). The best of the texts on general economics, from the standpoint of this book, is H. Clay, *Economics: An Introduction for the General Reader* (Amer. ed., New York, 1919). On the subjects of human wants W. E. Hearn, *Plutology* (Melbourne, 1864), old as it is, has never been surpassed; a recent book on this subject is Z. C. Dickinson, *Economic Motives* (Cambridge, 1922).

From the many works on economics a few only of those which have been helpful to the authors can be mentioned. Foremost in any list must rank Alfred Marshall, *Principles of Economics* (London, 1890; seventh edition, 1916), the standard work on this subject, but written for advanced students. The other books will be mentioned in alphabetical order. T. N. Carver, *Principles of National Economy* (Boston, 1921), is suggestive and designed for the general reader. C. S. Devas, *Political Economy* (London, second ed., 1901), written from the Catholic point of view, contains new and refreshing material. L. D. Edie, *Economics: Principles and Problems* (New York, 1926), contains a wealth of data on applied Economics. R. T. Ely and others, *Outlines of Economics* (New York, fourth revised edition, 1923), has been widely used as a college text. Fairchild, Furniss, and Buck, *Elementary Economics* (New York, 1926, 2 vols.), is the most recent survey of the whole field. C. Gide, *Principles of Political Economy* (New York, 1924), is a translation from the twenty-third French edition of a deservedly popular book. H. R. Seager, *Economics* (New York, 1913; third edition, 1923), is a clear and authoritative presentation. E. R. A. Seligman, *Principles of Economics* (New York, 1905; tenth edition, 1925), is scholarly and encyclopedic. F. M. Taylor, *Principles of Economics* (New York, 1921), is difficult but suggestive. F. W. Taussig, *Principles of Economics* (New York, 1911; third edition, 1921, 2 vols.), is judicial and thorough.

CHAPTER II

WANTS THE MOTIVE FORCE TO INDUSTRY

Why people work. — The most striking feature of modern industrial society is its ceaseless activity. On every hand are the products of past industry — buildings, roads, railways, bridges, telegraph and telephone systems, well-tilled fields, orchards and vineyards. Factories are equipped with complicated machinery, stores are filled with goods, theaters and other places of amusement are prepared to furnish recreation. And in spite of the vast accumulation of wealth which man has inherited from the past, he is continually striving to increase these stocks and to produce new forms of wealth. What is the driving force that urges — or, one may say, forces — man to exert himself, often, it would seem, against his inclination? It must be a powerful motive which daily marshals mankind to their various tasks in the fields, in the factories, in countless activities throughout the whole world.

The explanation is to be found in the needs, the wants, and the desires of man. In common with animals he has certain primary needs, for food and drink, for air and light, and for protection against cold. If these are not satisfied the human animal, like any other animal, must die; and if they are only partially filled, his powers, whether muscular or mental, will be proportionately enfeebled. The satisfaction of these needs is therefore a condition of life itself.

Nature does not provide a living. — It may be that in a few favored regions nature spontaneously provides sufficient food for the native population, and that the climate is so mild that no artificial protection against cold is needed. Such a situation, however, is very rare. Throughout most of the inhabited regions of the earth man has to struggle against an inhospitable environment, and must work hard to supply himself with the necessities of life. The goods which nature provides so freely and in such abundance that man may simply appropriate them for his own uses are called free goods. Such are air, sunlight, water in a free state, and a few other similar items. Those which cost effort, which can be bought only with a price, are called economic goods. A listing of the things which one needs and which cannot be had gratuitously would quickly show that these far outnumber the free goods. If free goods were sufficiently plentiful, if nature were only more generous, it might not be necessary for man to struggle for existence, to work for a living. But the plain truth is that nature does not provide a living for man, and that if he would survive he must work. " In the sweat of thy brow shalt thou eat thy bread." In order to satisfy his wants it is necessary for man himself to produce the material objects and the services which are needed for this purpose.

Man's dependence upon his environment. — Most of our wants constitute a draft upon the material universe outside of ourselves, that is, upon our environment. We have just seen that nature or the environment does not provide freely the goods necessary to satisfy even our primary needs. If everything were provided in sufficient abundance there would be a complete harmony, a perfect adaptation between man and his environment. But since this perfect adaptation does not exist there arises a struggle by which man endeavors to obtain from a too niggardly environment goods with which to satisfy his needs. This is called man's " struggle for existence," and has gone on continuously since creation between every form of life and its environment. By environment is meant all the conditions that affect the life of the organism, whether favorable or unfavorable. This would include such things as climate, temperature, rainfall, flora and fauna, mineral resources, nearness to transportation, character of neighbors, and other circumstances. Man's ability to gratify his wants depends in a considerable measure upon his environment. While he is not so dependent upon it as are birds and animals, his progress is conditioned thereby. The farther man has progressed from his original primitive state, the more he has emancipated himself from his immediate environment, and in some cases has even been able to modify it. Thus he has overcome the rigors of the climate by building warm houses, he has met lack of rain by constructing irrigation works, he has introduced plants and animals and improved their quality by selection and breeding. The importance and character of the environment, and the success of man's efforts in modifying and adapting it to his use, will be considered in subsequent chapters.

Man's peculiar power of providing for his wants. — In the case of all the animals below man, the satisfaction of their wants is wholly dependent upon the environment. They obtain such food and shelter as they can wrest from the resources about them, but they are unable to devise means to increase the supply of food or to improve their condition in other ways. The food of the cattle, the lair of the tiger, the cell of the bee, are the same as they were thousands of years ago, except in so far as they have been modified by the action of man. Instinct is the sole guide of animals in the meeting of their needs. Man alone has the faculty of improving the means with which to gratify his primary wants. "He alone has cooked his food. He alone has infused his drink. He alone has discovered new kinds of food or drink. He alone has improved the construction of his dwelling and has provided for its ventilation. He alone clothes his body, and varies that clothing according to the changes of temperature or his own ideas of decoration. He alone is not content with the mere satisfaction, in whatever manner, of his physical wants, but exercises a selection as to the mode of their satisfaction."[1]

Animals are content to meet merely their grosser physical needs, but man, as he develops, insists upon refinements of taste and form. He is not satisfied with food only, but wishes that food to be well prepared and served. A rude skin no longer meets his demand for clothing, but this must now be of softer materials and of pleasing design. The shelter of a cave or of a rude hut gives place to a commodious, well-lighted, and warm house. The progress of material civilization is marked by the steady development of higher types of the same kind of want. There is going on a constantly refining and elevating process.

A classification of wants. — A child is content with a bottle of milk and a warm covering, but as it grows older it demands a more diversified diet and many other things to gratify new longings. So it is with the human race. Primitive man was content with a handful of ripe fruit and a shelter under a tree, but as he progressed he developed new wants. Not only did he refine his physical demands for food and shelter and clothing, but he began to acquire new wants in connection with his developing mental and spiritual nature. The more he learned and the further he developed, the more numerous and various became these new demands. New wants of comfort, cleanliness, sanitation, education, beauty, recreation, travel, were developed with each succeeding generation.

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[1] W. E. Hearn: *Plutology: or the Theory of the Efforts to Satisfy Human Wants.* (Melbourne, 1864.)

Wants may be classified into " existence " wants and " culture " wants. The first of these comprises the purely physical needs which man shares with brute creation. The satisfaction of these needs is imperative, for upon them depends man's physical well-being, and even life itself. The " struggle for existence " centers around these elemental necessities, and to obtain them man will exert himself to the utmost. After these are satisfied, however, new needs and desires of a higher type — the so-called culture wants — awake in man. They are not instinctive, but are acquired with the progress of civilization. Yet as time goes on the culture wants become as imperative and intense as mere existence wants. Men will not infrequently deprive themselves of necessities in order to obtain comforts or luxuries. Indeed, it is very difficult to draw the line between the two classes, for after an acquired want has been gratified continuously for a long period it may become very urgent. It is a truism of history that the luxuries of one age become the decencies of the next, and the necessities of succeeding generations. Repetition and habit quickly entrench them as absolute wants. Thus there was a time when underclothing and forks and chimneys were considered unnecessary luxuries, although to-day each would be reckoned a necessity.

The expansion of culture wants. — As man progresses in knowledge he discovers new properties in the material resources of the physical world and finds that they can be made to minister to him. At the same time he develops his faculties and acquires new tastes and ambitions. Daily he makes new demands for the satisfaction of new wants, and as quickly as these are met others arise. Existence wants are limited, but there seems to be no limit to the number and variety of culture wants. Shrewd advertisers and salesmen are employed to arouse unsuspected longings and to display wares calculated to gratify them. But even without these artificial aids, every acquisition of knowledge, training of the faculties, or development of artistic or literary taste creates new demands. The appetite for learning, for books and pictures, for graphophones and automobiles, for travel and for similar things, is apparently insatiable and grows by what it feeds upon. Education widens the field of desire, and imitation and suggestion spread it from class to class and from person to person. A poor and illiterate person has only a limited number of wants and is incapable of imagining quickly the rational gratification of a large number. There is therefore likely to be foolish expenditure in case of the sudden acquisition of wealth by such a person. On the other hand, it is very difficult for a wealthy person, who has met with serious losses, suddenly to contract his demands for things which he has come to regard as necessaries. The standard of living is the expression of man's wants. Desire invariably outruns production; we always desire more than we can get. The satisfaction of our wants is limited by our productive capacity. Our standard of living is therefore the resultant of two forces — desires, which force it upward, and productive capacity or earning power, which holds it down. It is like a balloon tugging at a restraining rope, which will go as high as the rope will permit. The question has sometimes been raised as to whether unsatisfied desires lead to larger production, or whether the larger production, which permits the satisfaction of these desires, in turn gives rise to still further desires. Probably both statements are true; there is an interaction of economic forces here, as at so many points of our life.

The ascetic doctrine respecting wants. — Is this unlimited multiplication of wants desirable? Would it not be better if man should control his appetites, curtail his desires, and thus make smaller demands for the satisfaction of his wants? If new wants are constantly springing up as fast as the older ones are gratified, can there ever be an end to the struggle to produce wealth? Is the human race not on the treadmill of desire, which spins faster the harder man works?

These questions have been answered by the ascetic school in a very positive fashion. The Stoics of ancient Greece, the Christian ascetics of the Middle Ages, the Buddhists of the East, have all preached that the best solution of this problem is the reduction of our wants to a minimum. If we will only eradicate desires for temporal or material things from our minds, then we shall emancipate ourselves from our environment, and need not work so hard to produce wealth. This doctrine does not mean that we are to vegetate or retrograde to a savage state, but rather that we are to substitute higher wants for lower. That is, instead of finding our enjoyment in luxurious houses, expensive repasts, costly automobiles, or extravagant and ostentatious pleasures, we should lead a simple life and find satisfaction in good literature, in the beauties of nature, in the development of our spiritual and mental faculties. Such a doctrine does not necessarily mean withdrawing from the world and living the life of a hermit — which is an anti-social and undesirable act — but it does mean the reduction of material wants to a point which will leave the human race more time for leisure and contemplation. This ascetic philosophy has found widest acceptance in times and places where the struggle for existence has been most severe, and is perhaps explained by that fact.

Longfellow's Home, Cambridge, Mass.

The changing character of human wants is illustrated by the costumes of the people in this picture. If the scene were photographed to-day, an automobile would doubtless be shown where the carriage is standing.

The Occidental attitude toward wants. — In striking contrast with the view just stated is that held by most economists and people in the western world. These believe that progress will be secured rather by encouraging the development of new wants, with the resulting efforts to satisfy them, than by stifling or eradicating desire. Such a policy means, of course, labor rather than leisure; it means the application of effort and capital to the multiplication of material things. Our modern industrial society is frequently reproached with being materialistic; that is to say, with preferring material objects in the satisfaction of wants to the cultivation of a love for literature, or music, or art, or leisure. Whether rightly or wrongly, this is the tack which modern civilization is now taking. We live in a machine age, in a period of invention and discovery, of strenuous activity, and of pride in achievement, and we have developed cravings for the tangible results of our ingenuity and skill. Moreover, many of these products contribute essentially to our comfort and pleasure. Each new level of comfort and enjoyment stimulates new cravings. They grow by what they feed upon. Even after every known improvement has been made in the standard of living, agitation for betterment still continues and becomes more insistent. There seems little likelihood, therefore, that the western world will change its attitude toward human wants within any appreciable time, or will prefer a state of ascetic contemplation to one of action.

Unsatisfied wants the cause of economic activity. — It seems to be a biological as well as economic law that competition and struggle are the price of progress. If man does not exert himself he retrogrades. Races which make few demands and live indolent lives soon perish in the international struggle. Men who have no ambitions beyond the satisfaction of physical needs seldom rise high in the social or economic scale. The strongest incentive to endeavor which the human race knows is the driving force of unsatisfied desire. The more demands one has which call for gratification the harder one will work. Those nations and individuals, therefore, which have the highest standard of living, are also the most active and progressive. Since the wants which we feel and which we strive to gratify are our own personal wants, it is sometimes said that self-interest is the motive force of economic activity, and in general that is true. It is increasingly the case, however, that we are mindful of the needs and desires of other persons than ourselves, and find a motive to activity in the effort to gratify these. Whether the wants are our own or some one's else matters little.

Economics is concerned, we are told by a high authority, " with the satisfaction of those desires which are normally unsatisfied, which can be satisfied only through some conscious effort." [2] This is the explanation of modern industry, with its varied aspects of production, of commerce, of transportation, of exchange, and of distribution. Unless there were wants to call these activities into being, they would not exist. The motive to effort is unsatisfied wants; the means of satisfying these is human labor; and the result is human satisfaction. There is a daily round of human activities. Our unsatisfied wants force us to work; by work we turn our energies into economic goods or services; these goods and services are utilized to satisfy our wants, and by their satisfaction to restore our vitality and strength and fit ourselves for the morrow's tasks. Each day brings its quota of desires and work and rewards, and in a well-ordered life no one of these should overshadow the others:

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[2] T. N. Carver, *Principles of National Economy* (New York, n. d.), p. 37.

"*To get the whole world out of bed,*
And washed and clothed and warmed and fed,
To work, and then to bed again, —
Believe me, Saul, costs worlds of pain."

Moral function of wants. — It should not be concluded that human wants are incompatible with the development of our higher nature. It is not necessary to forswear the world and all its works, but it is desirable that our desires should be directed into channels which belong to our higher selves rather than to the purely physical side of our natures. Our fullest development will be attained, not by the repression, but by the refinement of our wants. Their satisfaction may lead to spiritual and intellectual growth. But even the satisfaction of our physical wants carries with it a certain moral discipline, which is especially marked in modern machine industry. This compels the development and practice of such virtues as patience, foresight, punctuality, forbearance, and above all coöperation. Thus the efforts which we must put forth to satisfy our wants lead to the development of our intellectual and moral faculties.

Character of economic motives. — By an economic want is meant not a dreamy wish to have something, but a desire coupled with a purposeful effort to obtain the means of gratifying that desire. The wish of a small boy outside a candy shop to have some of the wares displayed therein is not an effective economic want unless it incites him to action by which he can earn money to buy himself some candy. Building castles in Spain is not economic production.

The desire for material goods and services is the most prominent and persistent motive for economic action, but there are other motives which play an important part in our economic life.

The desire for esteem or for praise is a powerful motive in military, athletic, dramatic, and other similar fields of activity, but it also operates in the economic domain. Frequently what appears to be a desire for material wealth is really a wish to obtain applause for successful accomplishment, because this is usually measured by material possessions. Wealth-getting is thus a form of ambition. As an industrial motive, it is very potent.

Closely allied with this is the desire for power. Success in business, the amassing of wealth, confers upon the possessor power over other men and over the use of capital. Such a man is looked up to, and sometimes wields a greater influence than political rulers.

The desire for action generally results in play, but it sometimes finds a place in business. Many successful men find a strong motive for work in the excitement of the " game " of business. Work in general, however, is a form of action that requires some other motive than the pleasure of the action itself. The man is indeed fortunate who at the same time obtains from his work pay and pleasure.

Affection for those dependent upon us, an unselfish desire to benefit others, loyalty to a church, an institution, or an organization, patriotism to one's country, in a word, altruism or religion may act as a spur to work. Under the influence of these motives men will often work harder than they would for themselves.

The most persistent and powerful motive for economic activity is undoubtedly the desire for material goods and services. Even when the others seem to be dominant they are probably mixed with this one. The farther one gets away from the satisfaction of the primary wants, however, the stronger become the other motives, until in the case of our captains of industry they appear to control.

Conclusions. — From this brief survey we may conclude that man has wants which expand and increase with every forward step in civilization. These wants are not met by the free gifts of nature, but their satisfaction requires the production of economic goods and services. There is not enough wealth produced to-day to satisfy all the wants of human beings, and there probably never will be. We must, however, produce as much as possible in order to satisfy as many wants as possible. To do this we must endeavor by all means within our power to improve methods of production and enlarge the output of modern industry. How this is being done will be described in later chapters.

The desire to satisfy human wants is the motive to all economic activity, and in the Western world strenuous activity with its resulting rewards is preferred to a life of indolence and abnegation. Professor Carver has made the statement [3] that if the people of the United States were content to live to-day as did their fathers in 1876, we could probably reduce the average working day to four hours. But instead of decreasing our working day we have preferred to multiply material goods for the gratification of new desires. This may fairly be denominated progress. Unsatisfied wants are the spur to work, and it is only by work that we can satisfy these wants. The goal and object of economic activity is not work for its own sake, however; the sole purpose of all wholesome economic endeavor is the satisfaction and welfare of human beings.

SUGGESTIVE QUESTIONS

1. Name some instance in which the people live largely upon the spontaneous bounty of nature. Are these people progressive? Why not?
2. Make a list of the "free goods" which you used yesterday; now make a similar list of the "economic goods"? Which is longer?
3. Can you mention any instance of animals or insects devising means to increase their supply of food?
4. Distinguish between necessities, comforts, and luxuries.
5. Give some illustrations of the shift of luxuries into comforts, and of these into necessities. In which group would you place an automobile? A fountain pen?
6. Define standard of living.
7. Evaluate the Occidental attitude toward wants.
8. Is it true that there are no limits to the expansion of man's wants?
9. Why are some people able to gratify their wants more fully than others?
10. What motive today leads men to the most strenuous efforts to gain wealth?
11. Why do most millionaires continue to work after they have amassed fortunes?
12. Do you think that an increase in leisure would be more worth while than an increase in material wealth?
13. Which is worse, not to have abundant supplies of material goods or not to be able to enjoy them after you do have them?

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[3] "Have We Wasted Fifty Years?" in *World's Work*, July, 1926, p. 311.

CHAPTER III

SPECIALIZATION

Specialization a universal phenomenon. — The most marked and fundamental characteristic of the modern industrial world is specialization. It is the method by which man, with no larger expenditure of effort, has succeeded in increasing enormously the product of his labor. It is the key to the riddle as to how man has managed to satisfy his ever-expanding wants by increasing his productivity. Specialization means the concentration of the entire energy and time of a person, machine, factory, or district, upon the performance of one function or task. An explanation of this will go far in assisting us to understand the organization and working of modern industry.

Specialization embraces four distinct phases — territorial specialization, separation of occupations, functional specialization, and division of labor. The history of industrial development has meant the application of this principle on an ever-widening scale. Primitive society was composed of persons each of whom did practically what every other one did, but there was little connection between the separate units. To-day there is the greatest diversity of industry, trade, and profession, each person carrying on a highly specialized activity, but the individuals are organized in a unified and closely knit society. The movement from uniformity to multiformity of the units has been accompanied by an increasing integration and coöperation of the members of the group.

Territorial specialization. — By territorial specialization is meant the specialization of each region in the production of some commodity for which it is especially well fitted, and the exchange of the surplus of these commodities among the different regions. It is a geographical division of labor. Manifestly such a specialization could not take place until some system of exchange and of transportation had developed. In antiquity and in mediæval times only those articles could be transported for any great distance which contained a large value in a small bulk, and generally only those countries engaged in foreign trade which could make use of water transportation. Consequently territorial specialization was limited to those products which were confined to particular districts by reason of the existence of natural resources, as salt, iron, copper, etc., or of climatic conditions, as spices, drugs, cotton, wool, sugar, and other agricultural products.

With the development of the steamship and the railway, territorial specialization has taken on world-wide dimensions. Not only do different districts within a country specialize on certain products, as the cotton belt and the corn belt in the United States, but there is an international division of labor, according to which Japan exchanges silk goods for the hardware of England and the chemicals of Germany. Such a specialization greatly increases productivity and is the basis of the arguments of the free traders for the removal of artificial restraints upon free exchange among nations.

So great indeed are the advantages of this regional specialization that there has taken place in every country a striking concentration of industries in particular localities. Even within a city localization of industry takes place, and certain quarters or streets will be given over to particular trades. Briefly, the main advantage of territorial specialization lies in the creation of a specialized market for the sale both of highly specialized labor, of machinery, and of goods. In the case of some of the extractive industries, which are based upon the existence of a limited natural supply, nature itself has ordained a territorial specialization; in other cases it exists because it has been found advantageous.

Separation of occupations. — Historically, specialization first showed itself in the cleavage between the sexes.

In the earliest stage of development, namely, the hunting and fishing stage, the work of hunting and warfare not unnaturally fell to the man, while the preparation of food and the care of the household were assigned to the woman. The division of labor pictured by the fourteenth century poet, "When Adam delved and Eve span," was not true until a settled agricultural life began. Later there was a further separation of occupations among the males. A separate military class developed, which specialized in fighting, leaving industrial and religious functions to other classes. Where slavery was introduced the cleavage was very strong between the workers and other groups. This was true of classical Greece and Rome.

During the mediæval period in Europe agriculture was the principal occupation and society was organized in small village communities, called manors in England. In these there was only a rudimentary separation of occupations. Fully eighty-five per cent of the population were husbandmen, each of whom did practically the same work as his neighbors. A slight separation of occupations showed itself in the existence on such a manor of an ox-herd, a cowherd, a shepherd, a swineherd, a beekeeper, a cheesemaker, a smith, and a few other similar workers. But each manor was practically a duplicate of every other one, and there was no trade among them. Gradually a separate class of traders was differentiated from the farmers, and still later the artisan class separated itself, each group becoming in time more clearly distinguished from the others. The first industrial group to separate itself from the agriculturalists was probably the smiths, whose labors were essential after the art of smelting metals was discovered. It is perhaps significant that the only artificer in Olympus was Vulcan, the misshapen blacksmith. This separation was followed by the emergence of other distinct crafts.

Separation of functions. — The separation of society into distinct occupational groups increased the efficiency of each. This was followed in turn by further specialization within each group. The artisan class split up into a number of different industries, the smiths for instance being separated from the textile workers, and both of these from the leather workers. In the course of time each of these larger groups tended to break up into still smaller ones, the members of which specialized on some particular line of production within the general field. Thus we find among the craft gilds in England in the fourteenth century the leather industry separated into such allied trades as glovers, girdlers, pocket makers, skinners, white tawyers, and similar crafts; the bow and arrow industry was divided among the bowyers or makers of bows, the fletchers or makers of arrows, and the stringers, or makers of bowstrings. The existence of such crafts, some of which were followed by the same family for generations, is shown by the family names now in use, as the Smiths, Carpenters, Weavers, Taylors, Shoemakers, Bakers, and many others.

This functional differentiation finds many illustrations in modern industry. The textile industry is divided into spinning mills, dye works, and weaving establishments, each of which in turn may be devoted to the spinning of a special kind of yarn or to the weaving of a particular kind of cloth or carpet. The iron and steel industry ramifies into a dozen different branches, as blast furnaces, bloomeries, rolling mills, etc. These examples illustrate a succession of stages by which the raw material is carried through a series of processes until it emerges at last as a finished good. Another illustration of functional specialization may be found in the automobile industry or in the building of a steel steamship, where the different parts, as plates, bars, bolts, etc., are simultaneously produced by different groups of workers, and finally the parts are assembled into a finished whole. In all these cases there is a specialization of business units, which goes farther than the mere separation of occupations.

The conditions of specialization. — Under the earlier systems of industrial organization, specialization did not have the significance which it has acquired to-day. Under the old hand method of manufacture, a person often combined two or more types of activity. A farmer might at the same time make shoes or do the work of a smith. Also production was small because the market was limited. A person was not warranted at all times in devoting his entire time to the production of one article. Neither was there the complex system of marketing which we have at present. One person made the whole product and sold it to the ultimate consumer. Today the workers exchange their output with each other without direct sale to the purchaser. There is a complex system of exchange which takes these products from the producer and finds a consumer for them. At present all the people or organizations which handle a product or are concerned in any manner with obtaining the raw material, changing its form, and getting it to the consumer are specialists in their particular line, whether it be as farmer, miner, banker, merchant, manufacturer, or transporter.

The extent of specialization. — The tendency toward specialization is evidenced in practically all the activities of mankind, whatever their nature. We find it not only in manufacturing, agriculture, and commerce, but also in the professions. There are civil, mechanical, industrial, and electrical engineers; criminal and corporation lawyers; eye, ear, nose and throat specialists; teachers of economics, mathematics, history, science, etc. One might continue throughout the whole series of professions and would find in each a similar condition. In the field of finance there are commercial banks, trust companies, farm mortgage companies, savings banks, and investment banks. There are life, fire, accident, and fidelity insurance companies. Wherever one looks, this specialization exists. It is an evolutionary process, being possible only with the growth and expansion of the industrial and commercial organization, but it has completely changed the methods of the business world.

An example of specialization: marketing of wheat. — A few examples involving commodities with which most people are familiar will be given in order to show how occupations and functions have become specialized. The first illustration is the marketing of wheat. The wheat is produced by a farmer who in many cases produces nothing else, as in the great wheat regions, and thus is a specialist in that one commodity. He markets this by taking it to the country elevator where the shipments of many farmers are concentrated. The country elevator owner is a specialist in concentrating shipments. He ships the wheat to a commission firm at the terminal markets such as Chicago or Minneapolis, which in turn disposes of it to some terminal elevator company. Then it is sold to flour millers, breakfast food companies, and exporters. The flour millers and breakfast food companies change the form of the wheat and then send it on to the consumer through a chain of jobbers, wholesale houses, and retail stores. Each one of these persons or organizations has one particular function to perform in taking the wheat from the farmer and placing it in the form of bread or breakfast food in the hands of the consumer.

Another illustration: furniture manufacturing. — The production of a piece of upholstered furniture may be cited as another illustration which will show the specialization of business units. The tree from which the lumber is made is first cut by a worker who does nothing else. It is sawed into boards at the sawmill by another group of specialists. It is then sold and transported to a wholesale lumber dealer who sells the lumber to a retail dealer in whose plant it is planed and worked up into appropriate shapes. From the retail dealer it goes to a furniture factory. The finished piece of furniture reaches the consumer through a wholesale dealer and a retail furniture store.

But this is not all. Leather, tacks, stuffing, and glue are needed in making the chair. To make the illustration complete, we should go back to the cattle industry and the mining industry and trace the stages through which these products pass in acquiring a form or condition usable by the furniture factory. Likewise we might trace the production of any product required back through several series or ranges of specialists, and these might be divided and subdivided until the whole field of industry had been involved in the production of one product. The workers need food, clothing, shelter, and tools with which to work. Many other industries are involved in supplying these. This shows how complex the industrial organization is and how dependent one group is upon another. We could take any one product and before we were through recounting the groups which were either directly or indirectly involved in its production, we should have covered the whole field of industrial activity.

Economies of the specialized business unit. — It is evident that efficiency is greatly increased and output enlarged by the specialization of business units in particular lines. A shoe manufacturer who should attempt to carry on every stage of production from tanning the leather to marketing his product would find himself seriously handicapped both as to capital, as to the necessary knowledge of and skill in the various processes of manufacturing, as to facilities for marketing the shoes, and in other ways. The tendency in present day industry is more and more toward specialization upon one function.

Specialization in whatever sense we take it results, like every other improvement in business organization, in increased productivity and efficiency, and a cheaper product. If activities are confined to a narrow field, the workers in that field become much more proficient in performing their work than if allowed to spread out over a wider expanse of operations. All of the advantages of the division of labor and of the use of specialized machinery may be better obtained through the specialization of a factory. Specialization has resulted in a cheaper, better product, and a greater volume of products. A few illustrations will show the advantages to be gained.

In one case, the same machinery was used but the quantity of output was increased. This was in the manufacture of two oil pumps for hammer cylinders whose cost was $20.19 each. The pumps could be produced for $6.12 each, by manufacturing them in lots of twelve each. A further reduction would be possible if the quantity were further increased.

In the second case, different machinery was used. In the manufacture of one hundred ¾–inch by 4–inch hexagonal head bolts, by reducing on a turret lathe the body of the bolt from a bar of hexagonal steel of the size required for the head, the cost was $15.84. The same number of bolts was made for $5.88 by welding electrically the heads which were cut from a bar of hexagonal steel to the body of the bolt made from a piece of cold rolled steel the exact diameter of the bolt.

By specialization and the use of a new process the cost of cores for molds was in one case reduced from $1.18 to thirty cents each, others from fifty-six cents to fourteen cents each; and a third type from six dollars to ninety cents each.

The cost of manufacture by Edison of electric light bulbs, which at first was three dollars each, was reduced to less than twenty cents. Watches, which were once costly luxuries made by hand, are now manufactured in lots at a small cost. Through reduction of costs specialization has resulted in greater demand for products because each reduction in price brings a new class of consumers into the market. Many commodities which were at one time luxuries have been put in the class of comforts or necessities simply because of the reduction of costs.[1]

These economies result from a better adapted and more continuous employment of labor and equipment; a more economical use of raw materials; less expense in selling the product because variety is small and not so much expense need be incurred in acquainting people with the output of the factory; less administrative work, since a reduction in the variety of the products manufactured lessens the amount of attention and records necessary in order to determine which is profitable and which is not; and from advantages which may be obtained from transportation companies through buying raw material and selling finished products of uniform kind in large volume.

The dangers of specialization. — Although the advantages of specialization are far too important to think of doing without it, yet there are certain dangers which should not be overlooked.

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[1] These illustrations have been taken from an article by Alexander E. Outerbridge, Jr., in *Annals of the American Academy of Political and Social Science,* Jan.-June, 1905, p. 43.

Manufacturers have at times lost considerable sums of money by having the demand decrease for a specialized product which they were making. The possibility of being required to scrap relatively new machinery because of a new invention or discovery is another danger of specialization. Successful manufacturing to-day necessitates the possession of the most modern equipment possible. A new invention which will do the work better than the old machine will cause the latter to be discarded whether it is worn out or not. There are cases of a profitable plant having been put out of existence simply because its machinery was made useless by a new invention. Inventions have been made which reduced cost fifty per cent or more; and it is generally considered advisable to adopt a new process or invention if it will reduce the cost ten per cent.

Several years ago an English chemist discovered a new method for producing aluminum which would reduce the cost of production over fifty per cent. A new plant costing several hundred thousand dollars was erected, but before operations were well under way there was brought out an American electrolytic process which reduced costs to a fraction of what they were under the English method. This made the English process useless and the factory was abandoned.

Another illustration is the manufacture of steel for cutting tools. A few years ago a new method of treating steel for cutting tools was devised which caused a reduction of about four-fifths in the time required. Plants were built and equipped for employing this process. But they were made useless by the discovery of the alloys used to-day in manufacturing cutting tools, which made unnecessary the special treatment of the steel.

Another danger is the possibility of a new product making the old one useless. When automobiles first began to be manufactured they killed almost completely the bicycle manufacturing industry. The whole industry was threatened with destruction. Labor and management could in time find employment elsewhere and the factory buildings might house another industry, but much of the specialized machinery could be sold for scrap iron only.

Another danger results from temporary fluctuations in business prosperity. A period of business activity will cause increased production of articles for which later there will be no demand at their former high prices. A period of business depression will, if severe enough, cause a cessation of operations. In a highly specialized business, there is nothing to take up the shock. Where several articles are made, if the demand lets up for one, attention may be given to others, but in a specialized factory such is impossible. A highly specialized business is like a fast racing vessel, wonderfully speedy in a favoring breeze, but likely to capsize in case of storm.

There is also more danger of unemployment for a large body of laborers at one time. In specialized manufacturing, when depression comes on, or a lessening demand for their particular product, those plants which are manufacturing at the least cost will remain in operation. Others must suspend operations, throwing their laborers out of work. If a plant is making several lines of goods, these extra laborers might be employed to some extent in making some of the others still in demand.

Other dangers of specialization are those which affect the body and intellect of the workers and come about through the division of labor and the use of machinery. As these are dealt with in the chapters treating those subjects, they will only be mentioned in this connection.

The limits of specialization. — There are certain limits beyond which it is not advisable nor possible to carry specialization in manufacturing. In the manufacturing of men's shoes and suits a certain number of types are necessary because people's feet or bodies are of different sizes and shapes. Very likely it would not be practicable for a factory to specialize upon just one size of men's clothing or one size of shoes. The operations of manufacture can be carried out by the same person or the same machine on each size of product. Moreover, only a few are required of some sizes while large numbers are required of others; although these few odd sizes are very necessary, yet it would hardly pay one to organize a factory simply for their production. Better efficiency is obtained if all sizes of like products of this nature are made in one establishment.

The size of the market for a particular commodity also limits specialization in its manufacture. If specialization in the manufacture of any particular commodity be practicable it must be one which has a market extensive enough to permit of the organization of factories on a scale that will enable them to compete on an equal footing with other factories of like size which are manufacturing other goods. Otherwise there will be difficulty in securing all the factors required in production on favorable terms. Such being the case it would hardly be advisable to start a factory for the production of a single product.

The nature of the commodity made, whether it is a standardized product in general demand or a novelty or product subject to the changes of fashion, also limits specialization. Generally, there is much greater safety in building a specialized factory for the production of some article of necessity in general demand, than for building one to produce a novelty or luxury which has only a limited appeal or an article for which the fashion changes frequently.

But even in this latter case there can be some specialization. As an illustration, a plant for the manufacture of ladies' garments or hats may be taken. It can become specialized because a change in styles does not involve a fundamental change in methods and machinery. Such a plant simply gives the hats a different shape or different color, and cuts the dresses in a little different shape, making them a little longer or a little shorter, a little tighter or a little fuller, and of a different color. But where a change in the whims and notions of people might involve a complete change in methods and equipment within a short period of time, specialized production is not practicable.

Specialization also depends upon the prevailing form of economic organization. It was not possible under primitive methods because most of the requirements for its success were lacking.

SUGGESTIVE QUESTIONS

1. Does the community or state in which you live specialize in the production of one or more articles?
2. Inquire of the freight agent at the railroad station whether any things from your town are shipped to distant places. Whether any things are received from abroad or from distant places in the United States.
3. Describe the separation of occupations in your home; in the school.
4. Describe the separation of occupations on an average farm in your community.
5. Give examples of functional specialization in your neighborhood.
6. What, in your mind, is the chief factor making specialization possible?
7. List the different specialists who are employed in the manufacture of a fountain pen; in the production of a book.

8. Give an illustration from your own knowledge where specialization has reduced the costs of production, or the time or effort involved.

9. What risks does a factory incur by specializing upon one product? How can such risks be overcome?

10. Is the prosperity of a town or district in which one or a few highly specialized industries are carried on more or less unstable than one in which diversified industries are carried on?

11. Should a student train himself to be a specialist? Why?

12. What is meant by the phrase " Jack of all trades, and master of none "?

13. A large electrical company, desiring to attract students as workers, advertises: " Our large output enables us to make each man a specialist in his line of work." Explain why.

CHAPTER IV

DIVISION OF LABOR

Division of labor. — The final form of specialization is that which takes place in the case of individuals within a plant or a business unit. This is called technical division of labor. By this is meant the breaking up of the process of production of a commodity into a number of small parts, and the assignment of each part to a different worker. Instead of carrying through the production of an article from raw material to finished good, the workman is intrusted with a single operation, which he repeats endlessly. Complex processes are broken up into many operations, each of which is simple in itself; but the number will differ in different industries. Thus, in the making of a ready-made coat there are thirty-nine distinct operations; in the manufacture of a shoe there are over one hundred; in the slaughtering and packing of cattle about two hundred and thirty; while in the manufacture of a fine watch there are no less than one thousand and eighty-eight. Usually the workmen in such industries perform their tasks with the aid of machines, and the human contribution is reduced to the repetition of a single act like a thrust, a pull, or a blow.

An illustration from the manufacture of pins. — The classic example of division of labor is the description in the first chapter of Adam Smith's *Wealth of Nations,* published in 1776, of the making of pins, which he cited as illustrating in a remarkable manner the advantages of specialization.

" One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on is a peculiar business, to whiten the pin is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations. I have seen a small manufactory of this kind where ten men only were employed, and where

. . . they could make among them upwards of forty-eight thousand pins in a day. But if they had all wrought separately and independently, and without any of them having been educated to this peculiar business, they certainly could not each of them have made twenty, perhaps not one pin in a day."

A little over one hundred years later, in 1888, an American consul sent back from Germany a description of a pin-making machine,[1] which may well be contrasted with Adam Smith's account.

" The coil of brass wire is put in its proper place, the end fastened, and the almost human piece of mechanism, with its iron fingers, does the rest of the work. One machine makes 180 pins a minute, cutting the wire, flattening the heads, sharpening the points, and dropping the pin in its proper place. One hundred and eight thousand pins a day is the output of one machine. A factory visited by me employed seventy machines. These had a combined output per day of 7,500,000 pins, or 300 pins to a paper, 25,000 papers of pins. . . . These machines are tended by three men."

Meat packing as an illustration of division of labor. — In the meat packing industry may be found an example of the division of a process into minute operations, each of which is assigned to a separate worker in accordance with his strength and skill. This has been well described by Professor Commons.[2]

" It would be difficult to find another industry where division of labor has been so ingeniously and microscopically worked out. The animal has been surveyed and laid off like a map; and the men have been classified in over thirty specialties and twenty rates of pay, from sixteen cents to fifty cents an hour. The fifty-cent man is restricted to using the knife on the most delicate parts of the hide (floorman) or to using the ax in splitting the backbone (splitter); and, wherever a less skilled man can be slipped in at eighteen cents, eighteen and one-half cents, twenty cents, twenty-one cents, twenty-two and one-half cents, twenty-four cents, twenty-five cents, and so on, a place is made for him, and an occupation mapped out. In working on the hide alone there are nine positions, at eight different rates of pay. A twenty-cent man pulls off the tail, a twenty-two-and-one-half-cent man pounds off another part where good leather is not found, and the knife of the forty-cent man cuts a different texture and has a different " feel " from that of the fifty-cent man. Skill has become specialized to fit the anatomy.

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[1] Quoted by D. A. Wells: *Recent Economic Changes* (New York, 1889), p. 59.

[2] J. R. Commons, " Labor Conditions in the Meat Packing Industry," in *Quarterly Journal of Economics*, XIX, 3, 6.

" The division of labor grew with the industry, following the introduction of the refrigerator car and the marketing of dressed beef, in the decade of the seventies. Before the market was widened by these revolutionizing inventions, the killing gangs were small, since only the local demands were supplied. But when the number of cattle to be killed each day increased to a thousand or more, an increasing gang or crew of men was put together, and the best men were kept at the most exacting work. . . . Taking a crew of 230 butchers, helpers, and laborers, handling 1,050 cattle a day under the Union regulations of output, the time required for each bullock is equivalent to 131 minutes for one man, from the pen to the cooler, the hide cellar, and all the other departments to which the animal is distributed."

Advantages of the division of labor. — The general benefit of the division of labor is the increase in production and in material wealth which results. This increase in productivity is effected in the following ways:

(1) " The greater skill, dexterity, and judgment " of the worker were cited by Adam Smith, in the opening sentence of his famous *Wealth of Nations,* as the most striking effect of the division of labor. " Practice makes perfect." The constant *repetition* of the same operation produces in the operator a marvelous skill and dexterity which frequently awaken wonder in the mind of one unaccustomed to that kind of work. Illustrations may be found in the case of almost any machine operator, of a typist or a piano player, but the same qualities are also developed in mental work by sustained and earnest effort. Such skill may be in part inherited, as in the case of musical ability, but is usually acquired only by constant practice.

In order that the skill and ability of a person may be developed to the fullest extent, it is necessary that he specialize along some particular line. A Jack of all trades is proverbially master of none. This is well illustrated by the case of a pioneer farmer on the frontier of settlement. Cut off from easy communication with neighbors and markets, he cannot specialize his activities. He must produce his own food, build his own shelter, make his own clothing and shoes, and be his own blacksmith. The result is a smaller total product and a poorer living than he could obtain by concentrating on one thing. Forced to divide his time among different activities he can become proficient in none.

(2) Another advantage of the division of labor is that it permits the *assignment* of operations involving different demands upon strength, or judgment, or skill to persons of different abilities. By allocating tasks so that each works at the thing for which he is best fitted by nature or by training, there is a great gain in efficiency and in output. Some people are best adapted to mental work and some to physical; some are strong and others are weak. By a division of labor, appropriate tasks can be found for all, and on the other hand an employer can obtain the exact amount of force and skill necessary for any process.

(3) The division of labor means the simplification of each operation, and also the continuous employment of each worker at the same operation. There is therefore a *saving of time* both in learning a task and in shifting from one kind of work to another. Most operations connected with tending a machine are so simple that even the most unskilled laborer can be taught them in a few days. Under the old hand methods, an apprenticeship, extending sometimes through seven years, was necessary for the thorough training of a workman in his craft. Division of labor and the use of machinery have reduced the time of learning to negligible proportions, sometimes only an hour or so being required to learn a simple operation.

Time is saved also by eliminating change from one operation to another. A person cannot change tasks with full effect at first; he must " warm up " or become accustomed to the new operation before his powers are at their best. Frequent changes of this kind therefore involve a loss of efficiency as well as time, especially when new tools must be used or adjustments made.

(4) *Capital* is economized. Capital in the form of plant and equipment, as well as raw materials, is used more economically when processes are divided. If a worker moved from one operation to another he would presumably have to be provided with a different equipment for each task; but this would mean that some of the tools and machines would lie idle part of the time. If he were not thus provided, he would work less efficiently. In either case there would be a waste of productive resources. By subdividing the proc-

Entry Department in a Large Mail Order House

Here the customers' orders are copied on the individual tickets for each merchandise department which enables all departments to fill their respective parts of the orders simultaneously, and dispatch them so that all will arrive in the shipping department at the same time ready for packing in one shipment.

esses, and arranging the operations in a series, each employs his labor and equipment continuously, receiving a product from the one below him in the series and passing it on to the one above. Such a method permits also the use of more expensive and efficient machinery than would otherwise be possible.

(5) The need for analyzing the various industrial processes leads to labor-saving discoveries and *inventions*. One who puts in his entire time at one kind of work becomes very familiar with it and can see where improvements may be made or where an entirely new method may be employed. Inventions have sometimes been made by workers who sought to make their tasks less irksome. As complex processes are reduced to a series of simple operations, it becomes increasingly easy to devise machines to take over these operations from human hands.

(6) Finally, the division of labor aids man in securing and retaining the stock of *acquired knowledge* and experience which has been accumulated through the ages. " Without division of labor the inventions and discoveries which have made modern man's power over the forces of nature so much greater than that of his remote ancestors could not have been made, because no man would have had time to specialize sufficiently in the particular lines of study required. When the knowledge has been once acquired, it would often be lost if it were not for the existence of books and instruments . . . and of the exertions of a class of educators, which could not exist in the absence of a division of labor." [3]

Disadvantages of the division of labor. — Two main indictments have generally been brought against the division of labor.

(1) Extreme specialization has a *narrowing* and degrading effect upon the worker. Adam Smith himself, who first showed the importance and advantages of the division of labor, made the following charge: " The man whose whole life is spent in performing a few simple operations . . . generally becomes as stupid and ignorant as it is possible for a human creature to become." [4] The constant repetition of a single task not only means a terrible monotony in work, but also destroys all initiative on the part of the worker. His faculties are narrowed; he loses the ability to reason, and does not develop judgment or foresight. He becomes a mere cog in a machine which is organized and directed by a

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[3] E. Cannan: *Wealth,* pp. 50–51. [4] *Wealth of Nations,* Book V, Chap. I.

separate and distinct group; he himself has no share in this work of organization. Confined to a single operation, he misses all educational influences in his work and becomes stunted instead of developing in capacity as he grows older and more experienced. "It is a sad confession for a man to make," said Lemontey, a French writer, "that during his whole life he has never made anything but the eighteenth part of a pin." There is involved here not merely a harmful effect on the individual but also a serious social loss.

(2) Another evil is found in the extreme *dependence* of the worker, who is trained to perform some highly specialized task and becomes incapable of doing anything else. While he gains in skill he loses in adaptability. In a dynamic society where new inventions are constantly being made, where methods and processes are continually changing, an 'all round' man is needed rather than a specialized human machine. Moreover the worker himself is exposed to the risk of having his skill rendered valueless by some improvement.

Limitations to the division of labor. — There are certain factors which determine the extent to which the division of labor in any industry or plant may be carried.

(1) In the first place the division of labor is limited by the *extent of the market.* Specialization of occupations or of industrial plants or of individuals will clearly stop at the point where demand for their product ends. Thus in a small town a physician has a general practice, but in a city he becomes an eye-specialist, a surgeon, or other kind of specialist. The specialization of industrial plants will be carried farther in a large market than in a small one. Similarly the division of labor within a plant will be limited by the ability to market the good produced; at any given time a point will be reached in every industry beyond which it would not be profitable to carry the division of labor. This explains the eagerness of industries to enlarge their export trade; with the whole world for a market they can carry the division of labor to its fullest extent. The extent of the market is in turn obviously limited by the stage of development of means of transportation and by the nature of the product. In a country with inadequate transportation facilities, whose population is scattered and separated, the market will be a narrow one. Again, if the product is a novelty for which the demand may soon change, or a perish-

able good which must be sold quickly, the market is smaller than for a standard or durable commodity.

(2) The division of labor is limited also by the *nature of the work*. Thus in the case of wheat growing the ground must first be plowed and then harrowed; in about eight months — if it is winter wheat — the grain must be harvested and then threshed. Each of these operations must wait on the completion of the one preceding it; there could not possibly be a division of labor on the part of wheat farmers under such circumstances. If a man specialized as plower, or reaper, or thresher, he would be idle eleven months in the year. Wherever work is seasonal in character, this limitation exists.

(3) The extent of the division of labor will also depend upon the command over an adequate *supply of labor, of capital, and of managerial skill*. There must be sufficient workers to permit the distribution of specialized tasks to separate individuals. The amount of capital will determine the size of the plant and the extent to which specialized and expensive machinery can be employed. And both these will determine whether high-priced managerial skill will be profitable. From a social point of view, on the other hand, the amount and quality of managerial skill in a country places very definite limits upon the extent to which division of labor can be carried.

(4) Finally, the *nature of the existing economic order* may have some influence on the division of labor. Under a system of free competition or freedom of industry, each individual is at liberty to select his own employment and to conduct his affairs in accordance with his own self-interest. This has led to extreme specialization. It is conceivable that in other systems of industry, governmentally controlled or socialistically organized, division of labor might not be pushed so far.

Conclusions as to division of labor. — The great social gain from specialization and the division of labor is increased productivity; the return from a given amount of work is increased. Upon this increase of wealth rests the material improvement of society. A higher standard of life is thereby made possible. Although certain evils have developed, these may be greatly mitigated, if not entirely removed. The monotony and narrowing effect of a repetitive task are offset by a shortening of the working day, the increase of leisure, and the possibility of employing this leisure time in a more satisfactory way. The economic dependence resulting from too great specialization needs to be met by a better system of general technical education, which will teach men adaptability as well as specialized skill.

The great danger that lies in extreme specialization is more general in its nature. This is that the workman will be treated simply as a part of the economic machine; that he will be regarded as a means to production instead of production being regarded as a means to satisfy his wants. Work instead of welfare seems to be regarded by some persons as the object and goal of our economic activities. It must be insisted, however, as was pointed out in the first chapter, that human satisfactions are the purpose of our endeavors. Material goods must not be purchased at the expense of human suffering or degradation. On the other hand society cannot afford to give up the advantages of the division of labor. This beneficent principle must be fully utilized in the interest of the material improvement of society, but it must be stripped of abuses and used for the well-being of all members.

SUGGESTIVE QUESTIONS

1. Describe the division of labor in the manufacture of some product with which you are familiar.
2. Show the relationship between the division of labor and the use of machinery; between division of labor and large scale production.
3. Name some instance where constant practice has made you, or some acquaintance, skillful in doing some thing.
4. Do you know of any case where a crippled or invalided person has found special work adapted to his ability?
5. Are the benefits from the increase in the production of material goods greater than the disadvantages mentioned in the text, or less?
6. Which worker is more desirable socially, the specialist who has concentrated on one thing, or the person who knows something of several different types of work?
7. Tell how far division of labor has proceeded in your home town.
8. What limits exist in your home to the division of labor among different members of the household? Do you think further specialization would result in economy of time and effort?
9. In Europe, the housewife takes a basket on her arm and goes to market; in the United States she telephones her order and has the merchant deliver the household supplies. Account for the difference.
10. Suggest methods for overcoming some of the evils resulting from the extreme division of labor.

CHAPTER V

INTERDEPENDENCE A CHARACTERISTIC OF MODERN INDUSTRY

Specialization involves dependence. — It is obvious that if a man specializes in one occupation he cannot carry on others. He may be capable of doing a dozen things equally well, but it pays him better to concentrate on one specialty and perfect himself in this. By this very act, however, he becomes dependent upon other persons to provide him with the goods and services whose production he foregoes. This dependence is one of the most striking characteristics of our modern industrial system and is in evidence from the time we get up in the morning until we go to bed at night. Most of us are related to the business world in two ways: as workers we are attached to some particular kind of business, and as consumers we are related to a great number of industries and trades. "All society," it has been said, "is in fact one closely woven web of mutual dependence in which every individual fiber gains in strength and utility from its entwinement with the rest." The daily routine of the ordinary business man will make this clear.

When John Doe has finished dressing himself in the morning, one of his first acts is to step outside the door and bring in the newspaper and milk which have been left by the newsboy and milkman before he was awake. After breakfast he boards a trolley car which conveys him to his work. This he carries on in a building in whose construction he had no share, with tools, or desk, or goods which he did not produce. At noon he eats a lunch prepared for him in a restaurant by persons he has never seen. After his day's work, he takes his wife to a motion picture show, the film for which was produced two thousand miles away from his home and as to whose very existence he was ignorant until this night.

Dependence means interdependence. — It is not to be concluded from this picture that John Doe has not himself been working, for he has put in a busy day. But he has probably not consumed any of the things that he has produced; these are destined to be used by other people. For his work he has received his pay in so many dollars, which he has exchanged for the products or services of others. In modern industry dependence is not unilateral, to use a legal term; it is always bilateral. That is to say, it is a two-sided arrangement, and does not involve only one party. The care for a child by its parents, the presentation of a gift, the maintenance of defectives in a state institution — all these may be regarded as unilateral, that is, one-sided. But the mutual dependence of the members of a modern industrial society implies reciprocal exchange of commodities and services. There are few parasites in our busy workaday world, who simply " sponge " upon society for a living without giving a fair exchange. The specialist may count with assurance upon having his wants along other lines supplied, if he will produce a supply of his specialty for the use of others. As industry is now organized this is not dictated by a feeling of unselfishness or benevolence, but each worker is guided primarily by his own self-interest. On the whole, however, this system works out for the benefit of all parties concerned. If a man wishes to earn wages or to sell goods, he must observe what services or what commodities other persons want and offer to do that work or furnish those goods in order that they may be willing to remunerate him. Thus he serves them while helping himself.

Dependence, as thus defined, does not mean that some persons become a burden upon others. A one-sided dependence involves either charity, where the strong support the weak, or slavery, where the strong are supported by those who are legally and economically weaker. Dependence in a system of free competition and individual enterprise means interdependence. The economic world in which we live to-day is bound together by a perfect network of mutual relationships which in some degree involve the dependence of every one upon other persons. " A man can not be rich and busy when all his neighbors are idle and poor," said David Hume. Interdependence means a mutuality of interests.

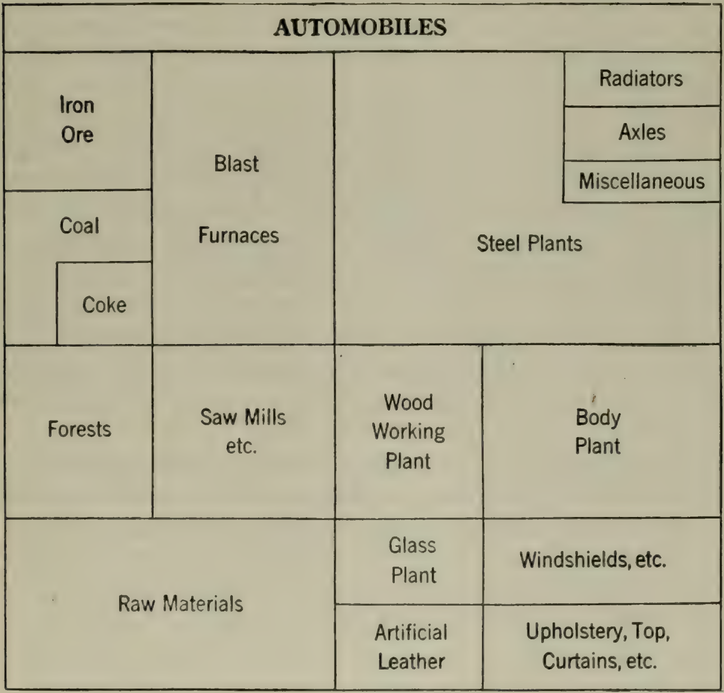
Interdependence of individuals. — In a primitive society where there is little specialization or division of labor, there is also little interdependence. This may be illustrated by reference to the medieval manor. As has been stated, the manor was a small agricultural community, in which practically all the workers carried on identical agricultural labors. There was little division of labor and practically no exchange. Each family produced by itself and for itself almost all the food, clothing, fuel, shelter, and other goods which it consumed. If one individual or family had stopped producing it would have made little difference to the other members of the manor, for there was little interchange of goods or services and consequently little interdependence. The same thing was true of the pioneer farmers in the American colonies. Isolation developed independence, and fostered qualities of resourcefulness and initiative.

It has indeed been urged as an objection to our modern system of interdependence that it weakens the stamina of individuals, who become too much accustomed to leaning on others. In answer to this it may be urged that dependence does not mean supineness; that interdependence involves a " give " as well as a " take." It implies a reciprocity of effort. The pioneer's sustenance and comfort depended directly upon his own effort; and was greater or less according to his own strength and ability. But the modern worker's supply of goods from others depends also upon his own efforts, even though he does not produce them directly; for the more efficient and skilled he becomes in his specialty the larger is his pay and the more commodities and services produced by other people can he command.

Interdependence within a business. — Every industrial establishment is organized in such a way that each worker and each machine occupy a definite place in a related scheme of things. A student who should get a job in the summer in a factory would probably be somewhat perplexed at first by the apparent confusion and the intricacy of operations about him. But if he were an observant young man he would soon learn that the operation which he performs is definitely and closely related to those performed by other workmen from whom he receives a piece of material or to whom he passes it on. As he looks about he finds a large building on a considerable piece of land; the factory is equipped with motive power, machinery and tools, raw materials, and products in various stages of manufacture. If he gets beyond the workrooms he will find an accounting department, perhaps salesrooms, with a staff of clerks, and executive offices.

It must soon become apparent to such an observer that each of these different parts is dependent upon the others and that together they form a coherent whole. Within a single business the interdependence is very great, and no single department or even operation could be spared.

If, instead of a factory, the student had gone to work in a mercantile establishment, a retail store, a mine, or on a farm, he would have found a similar material structure of the business and a like interdependence of its parts. In the store the personnel would have been more numerous, while in the mine or on the farm land would have bulked more largely, but in all of them the different parts would work together. Some businesses, like a railway or that of a building contractor, are not confined within definite premises, but consist of geographically widespread operations; yet even in these cases the interdependence of parts is real and close.



Organization in the Automobile Industry

Interdependence among businesses. — Our student worker would soon have discovered that not merely were the parts of his factory interdependent, but that the business as a whole was vitally dependent upon other concerns both for its raw materials and equipment and for the sale of its products. A shoe factory may be taken as an illustration.

Such an establishment uses leather as its principal raw material in the manufacture of its product. But the leather is obtained from another manufacturer, the tanner, to whom it appears as a finished good; and he in turn got the hides from some jobbing house, which imported them from a ranch owner in Argentina. In addition to the leather the shoe manufacturer requires supplies of oil, cloth, nails, eyelets, thread, rubber, and many other things. If the life history of each of these were traced back to its birth, it would be found that each one reached back to some extractive industry, such as that of the rancher, farmer, miner, lumberman, and others. The manufacturer of shoe machinery, who equips the factory, stands at the head of another long row of industries.

But this is only half the picture. The shoe manufacturer sells his product to wholesalers, who possibly sell in turn to jobbing houses which distribute the shoes of many similar firms to the retailers, from whom they finally pass to the consumer. The shoe factory thus stands in the middle of a long row of related industries, each of which is dependent for its success upon the prosperity of the others. The failure of any one would be reflected both backward and forward along the whole line. At one end of this line stands the producer of the original raw material; at the other the ultimate consumer, whose satisfaction is the goal of all this diverse activity.

Interdependence among nations. — Just as specialization by individuals leads to interdependence among them, so territorial specialization involves the mutual dependence of different localities, regions, countries, and nations upon each other. The corn belt, the wheat belt, or the cotton belt in the United States, each of which devotes itself primarily to the production of a single commodity and ships this to other sections of the country and even to foreign countries, depends in turn upon these for the supplies of manufactures and other goods which it needs. The wheat raised by a Minnesota farmer may some day make the bread eaten by an English cotton spinner, a German chemist, and a Swiss watchmaker, and he may buy with the money received for his crop the products of these workers. This may be regarded as a more or less accidental interdependence, but there are many cases where it is as real as the interdependence within a factory. The dependence of the American farmer upon German potash salts, of the automobile manufacturer upon East Indian rubber, of the manufacturers of tin cans upon supplies of tin from the Straits Settlements or from Wales have their counterpart in the dependence of the Germans for our canned meat, of the Brazilians for our manufactures, and of the British for our grain. In many cases this interdependence is unconscious, but it is none the less real. International commerce is only an expression of these reciprocal relations between nations. Even more close, of course, are the relations of mutual dependence between the different sections of a single country, as between the shoe districts of Massachusetts and the citrus districts of California.

Transportation is the connecting link. — Dependence implies connection. No relationships of interdependence between different businesses or different regions could exist without means of communication and transportation. In the mediæval manor, where each family produced for itself practically everything it consumed, there was little need of transportation, certainly not of distant transportation. But as soon as division of labor and specialization took place, more particularly territorial specialization, then adequate transportation came to be of the first importance. And the more efficient and cheap the methods of transportation became, the further the territorial specialization could go. But with every lengthening of the lines of communication, with every separation in space of sources of supply and consumption, just so much more necessary becomes transportation.

Great Britain, a highly industrialized country, is absolutely dependent upon other countries for her foodstuffs and for the raw materials needed in her manufactures, but such dependence is unthinkable apart from railways and steamships. How vital continuous transportation is to her very existence was illustrated by the perils to which she was put by the German submarines during the World War. The same thing is illustrated on a smaller scale in the case of any large city which depends upon outside sources for its supplies of milk, food, coal, and other supplies. Any interruption to the railway traffic leading into New York City, for instance, would mean privation within twenty-four hours, and starvation in a week. It is only by improved transportation systems that the scattered individuals, businesses, and regions are linked together into one unified economic whole.

Exchange involved in interdependence. — In the foregoing discussion of interdependence, it has been assumed that exchange of products would take place between the specialized producers. It is indeed obvious that specialization would be impossible without exchange. There could be no separation of occupations, as between farmers and manufacturers, or between carpenters and shoemakers, unless some method were established by which these respective workers could exchange their products. Nor could there be any specialization of plants on a particular line of production, nor of geographical regions on some local product, unless each specialized plant and territory were certain, not merely that it could market its own wares but also that it could obtain from other plants and territories, which had specialized in other lines, the products of which it stood in need. Division of labor, most of all, depends upon the existence of organized markets and of a highly developed system of exchange. The manufacturer of plows would die of hunger if he could not count upon the labor of the farmer, and the labor of each workman in the plow factory would be vain unless other workers in other industries did their part.

Modern specialized industry is based upon the existing system of exchange, whereby each worker produces goods which he himself does not expect to consume, and then depends upon other workers to supply him with the commodities he needs. Manifestly the different sets of workers do not exchange their goods directly, by means of barter. The workers are paid wages, with which they buy consumable goods. The manufacturers, or other producers who have hired the laborers, sell the manufactured goods in the market for money, which they in turn spend in part for their own needs and in part for more raw material and wages and other expenses to produce another supply of goods. Money and credit, banks and other financial and commercial institutions, provide the machinery whereby these exchanges, sometimes between opposite sides of the earth, are effected. At basis, however, the things which are exchanged are commodities and services; money is only the medium by means of which the exchange is made easier. But in such a complex industrial system as ours to-day money is essential as a basis of exchange.

Organized markets are also necessary in a system marked by specialization and interdependence. These may be world markets, such as exist in the case of wheat or cotton, or local retail markets, like a neighborhood grocery store, but in either case they are recognized centers where specialized products can be disposed of or where consumers can purchase the goods which they need. The organization and functioning of these markets is so important that they will be dealt with more fully in a later chapter.[1] It is sufficient at this point to indicate their relation to the interdependence of specialized producers.

The interdependence of prices. — The intricacy, the intimacy, and the delicacy of the industrial mechanism are perhaps best illustrated by the interdependence of prices, and of other factors through the medium of prices. The demand for most goods depends upon the price asked, and this in turn depends upon the prices of raw materials, of machinery, of buildings, of labor, and other factors that enter into their production. A change in any one of these, whether up or down, is reflected in the price of the finished product. Thus a fall in the cost of raw cotton will make for cheaper cotton goods, or a rise in bricklayers' wages may cause a rise in the rent of apartments. There is a sympathetic relationship between industries which is registered in price changes, as when a rise in the price of sugar causes the failure of jam factories, or an increase in the cost of tin plate affects the salmon-canning industry. There are also collateral effects, in the way of substitution; if beef is too high, we eat more pork; if all meat is high, we become vegetarians.

The price of any good is thus dependent upon the prices of many other goods. And this is true not merely of past prices, but also of probable future prices. Thus the rumor of the discovery of a new oil field may send down the price of gasoline. The interdependence of prices is perhaps best illustrated by the far-reaching effects of a price disturbance at any point. Thus a coal strike with a resulting advance in the price of coal may cause not only suffering in the homes of the poor, but a curtailment in the production of steel or a rise in the price of steel rails. Price changes reach forward and back in a long range of reciprocal relationships that extend from the extractive industries to the final consumer.

Capitalism increases interdependence. — In a primitive agricultural community, such as the early English manor, where little capital was used, production was direct. That is to say, the labor of the husbandman was applied directly to the soil with the aid of a few rude tools. Little time was devoted to inventing or fashioning better implements or to devising improved methods. As civilization advanced, however, more time relatively began to be given to the preparation of better instruments of production and less to that expended upon the final product. For example, a member of the manor drew his water with a bucket directly from a stream. The bucket was the only capital that was needed in this case. But to supply a resident in a modern city with water involves a vast series of preliminary labors: a neighboring stream must be dammed up; the impounded water must be conducted through an expensive aqueduct or series of mains to the city; it must then be pumped under high pressure into the city mains; elaborate and expensive systems of plumbing must be placed in all buildings; and finally, in order to care for the dirty water after it has been used, almost equally elaborate and expensive systems of sewage disposal must be provided. All this in order that the user of water may have it ready for use by turning a faucet. In this case years of preparation and vast amounts of capital have been employed in the preliminary stages, in merely providing the means by which the water is to be obtained. Such a process has been called the "round about" method, or it may be called capitalistic because it involves the large use of capital.

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[1] See Chap. XXXVI.

It is clear that the more capitalistic a society becomes, that is, the more people are employed in making machines for future production of wealth, and perhaps even machines to make machines, the more interdependent are the members of such a society. The interdependence reaches forward and back in point of time as well as in a series of simultaneous acts of production. The brickmaker produces bricks for building an aqueduct that will take twenty years to complete; between him and the users of the aqueduct is an act of dependence, stretching over that length of time. The more capitalistic a society becomes, the more distant and impersonal become the relations between its members, and the more unstable and delicate its mechanism.

SUGGESTIVE QUESTIONS

1. Enumerate some of the persons or industries upon which you are economically dependent.

2. What proportion of the commodities or services which your father produces are consumed in your family?

3. Define an industrial society.

4. Give some examples of economic parasites in our industrial system. Is a high school or college student a parasite?

5. Explain what Hume meant when he said, " A man cannot be rich and busy when all his neighbors are idle and poor."

6. Illustrate, from some business with which you are familiar, the interdependence of the different workers; of the different departments.

7. Illustrate the interdependence of industries by showing what takes place when there is a general coal strike; a railroad strike.

8. Does a self-sufficient household or community have any advantage over a specialized one? Is it subject to any disadvantages?

9. Are there any obstacles to the smooth working of interdependence among nations?

10. Is there a loss or a gain in the system by which cotton is grown in the United States, made up into cloth in England, and perhaps consumed in Australia?

11. Explain why a rise in the price of sugar may cause a failure of jam factories.

12. State how a railway strike might affect the price of some of the articles which you consume.

13. Define capitalism. Distinguish it from other stages of production.

CHAPTER VI

COÖPERATION

Coöperation fundamental in modern industry. — Simple coöperation takes place when several men work together for the performance of a task which would be beyond the powers of any single one, as among the colonial pioneers who united for a roof-raising, the stepping of a mast, or similar tasks. A more complex and indirect form of coöperation occurs when various persons work at different operations in the production of a given commodity, sometimes separated from each other in time and space. Thus men may work in succession, as in the case of the team system in the clothing industry, by which each process in the making of a coat or other garment is performed by one set of workmen and the article is then handed on to the next set for the next operation. Or the different operations may be carried on simultaneously, as by the workers on a railroad or in a steel plant where all must act together on a given signal. And finally different regions in distant parts of the earth which specialize on particular industries and then exchange the surplus products with each other may be said to coöperate with each other in the satisfaction of human wants. Each contributes his share to a joint enterprise, and each in turn receives his share from the others. Specialization or division of labor, therefore, when looked at from the social point of view, is really combination of labor or social coöperation. Specialization, with its resulting interdependence, would be unthinkable without coöperation.

Statue of Coöperation in Ghent, Belgium

It must be admitted, however, that although production is truly a social process, the average worker is not aware that he is taking part in a coöperative undertaking. He is intent upon his job and does not look far beyond it; he receives wages and spends them for consumable goods, and that's all there is to it. Even if he be a little more thoughtful, he probably thinks of himself only as one of a number of workers who are producing goods for his employer. Coöperation there is between him and his fellow workers within the plant; that he can see. But it takes considerable imagination to picture himself as a coöperator in a great national or world organization which is producing goods for the satisfaction of the wants of a nation or for all mankind. For an adequate understanding of this fact it is necessary to turn to the explanation of a trained economist.

An illustration of social coöperation. — It would be possible to illustrate this principle of social coöperation from almost any act of production, or bargain and sale, or professional service, if we should take the pains to analyze it carefully. This has been done so effectively by Adam Smith, the famous English economist, writing over a century ago, that there is no need for another writer to use his own words on this subject.[1]

" Observe the accommodations of the most common artificer or day-labourer in a civilized and thriving country, and you will perceive that the number of people of whose industry a part, though but a small part, has been employed in procuring him this accommodation, exceeds all computation. The woolen coat, for example, which covers the day-labourer, as coarse and rough as it may appear, is the product of the joint labour of a great multitude of workmen. The shepherd, the sorter of the wool, the wool-comber or carder, the dyer, the scribbler, the spinner, the weaver, the fuller, the dresser, with many others, must all join their different arts in order to complete even this homely production. How many merchants and carriers, besides, must have been employed in transporting the materials from some of these workmen to others who often live in a very distant part of the country! How much commerce and navigation in particular, how many ship-builders, sailors, sail-makers, rope-makers, must have been employed in order to bring together the different drugs made use of by the dyer, which often come from the remotest corners of the world!

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[1] Adam Smith, *Wealth of Nations,* Book I, Chap. 1.

What a variety of labour, too, is necessary in order to produce the tools of the meanest of these workmen. To say nothing of such complicated machines as the ship of the sailor, the mill of the fuller, or even the loom of the weaver, let us consider only what a variety of labour is requisite in order to form that very simple machine, the shears with which the shepherd clips the wool. The miner, the builder of the furnace for smelting the ore, the feller of the timber, the burner of the charcoal to be made use of in the smelting house, the brick-maker, the brick-layer, the workmen who attend the furnace, the millwright, the forger, the smith, must all of them join their different arts in order to produce them. Were we to examine, in the same manner, all the different parts of the dress and household furniture, the coarse linen shirt which he wears next his skin, the shoes which cover his feet, the bed which he lies on, and all the different parts which compose it, the kitchen grate at which he prepares his victuals, the coals which he makes use of for that purpose, dug from the bowels of the earth, and brought to him perhaps by a long sea and a long land carriage, all the other utensils or pewter plates upon which he serves up and divides his victuals, the different hands employed in preparing his bread and his beer, the glass window which lets in the heat and the light, and keeps out the wind and the rain, with all the knowledge and art requisite for preparing that beautiful and happy invention, without which these northern parts of the world could scarce have afforded a very comfortable habitation, together with the tools of all the different workmen employed in producing these different conveniences; if we examine, I say, all these things, and consider what a variety of labour is employed about each of them, we shall be sensible that without the assistance and coöperation of many thousands the very meanest person in the civilized country could not be provided, even according to what we very falsely imagine the easy and simple manner in which he is commonly accommodated. Compared, indeed, with the more extravagant luxury of the great, his accommodation must no doubt appear extremely simple and easy; and yet it may be true, perhaps, that the accommodation of an European prince does not always exceed that of an industrious and frugal peasant as the accommodation of the latter exceeds that of many an African king, the absolute master of the lives and liberties of ten thousand naked savages."

The ramifications of a coöperative society. — Long as is this list of ways in which other people coöperate to supply a day-laborer with his daily necessaries, it has been greatly lengthened in the century and a half since Adam Smith wrote this description. To-day this laborer's descendant is able to send his children to a public school, which involves not merely the construction of school buildings, but a long anterior series of acts which have led to the education and training of the teachers. His home is furnished with water and light; the streets of the town in which he lives are paved and lighted. Courts of law are available to render him justice in case of disputes; policemen and firemen guard his property; soldiers and sailors protect him from foreign aggression. To carry on the businesses which provide for his needs, there are called into existence several series of institutions — banks, brokers, jobbers, wholesalers, and other specialists in finance and distribution; salesmen, advertisers, writers, newspapers, magazines, and other agencies for making known the finished goods; steamships, railroads, and delivery trucks, with all their crews and drivers. There is apparently no end to the workers whose services are called into play to provide even the simplest necessities of a poor man.

The most extraordinary feature of this coöperative enterprise which we call modern industry is that every other worker is in the same situation as our day-laborer. In spite of the fact that he obtains from others more than he could himself produce in ages, there is no robbery. He has earned all that he has received, as have all other members of society. This is the result of coöperation in modern industry.

All production in industrial society is coöperative. — It is sometimes said that the laborer is entitled to what he produces. An analysis of this statement will illustrate still more clearly the extent to which all production in modern industry is coöperative. In a more primitive stage of industry it may have been correct to say that a man produced the woolen coat that he wore, for he reared and sheared the sheep, washed and combed the wool, his wife spun and dyed the yarn, which he probably wove into cloth, and fashioned and sewed the coat. Under such circumstances we may say that the laborer produced the coat and that the laborer's income consisted of the coat and other similar things which were the direct result of his labors, although even here he used tools and implements which were made by other workers.

But in a modern factory it is manifest that the workers cannot take their pay in the things which they produce, for they could neither use them for themselves nor exchange them advantageously for other things. Is it true, however, that the spinner " produces " the yarn or the weaver the cloth? To assert this is to lose sight of the long series of acts of production which brought the raw wool to the state where it could be spun or woven. If an effort is made to distribute the finished product — the woolen coat — or its value among the various workers who have contributed their labors directly to its manufacture, another difficulty is met. What share belongs to the soldiers, policemen, judges, and others who have maintained peace and order while the coat was being manufactured? What share belongs to the owners of the land, of the buildings, of the machinery with whose assistance the work was carried on? What, if any, belongs to the inventors, to the educators, and still others who have contributed in their ways to the final result?

It is obvious that it is impossible for any worker to assert a claim to any product or any part of a product, on the ground that he alone has produced it, because all production in modern industry is social and coöperative. The national income is the sum of all the products which have been produced by society; this belongs to the whole of society. Just how it is distributed among the different individuals who make up society is a problem which does not belong here.

Qualities necessary for coöperation. — We are so accustomed to specialization and division of labor with its resulting coöperation that we accept them as a matter of course, yet it was only after many ages of hard experience that the members of the human race learned the value of coöperation. And even to-day many men lack the qualities which are necessary for successful associated action. The most important of these are the following: [2]

(1) Honesty. If there is mutual distrust, coöperation is impossible, for this is based upon mutual confidence. In certain countries, such as Turkey, personal honesty is still so uncertain that economic progress is hindered. In western Europe, Australia, North America, and other parts of the world it is so universal a quality among the working population that it is assumed as a matter of course.

(2) Dependableness. Men cannot work in coöperation unless

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[2] *Cf.* H. R. Seager, *Principles of Economics,* 2nd ed., p. 135–138.

they can depend upon their fellows carrying out their allotted tasks. There are involved in this quality such economic virtues as steadfastness in purpose, punctuality, sobriety, and other factors which indicate that the man is reliable and can be depended upon to live up to his responsibilities. This quality is particularly needful in the modern factory system.

(3) Obedience. This is a quality which is of especial value in soldiers but is essential also in the industrial army, whose members are marshalled by tens and hundreds and even thousands in shops and factories under the direction of superiors.

(4) Spirit of conciliation. Working together often produces friction and disagreements; successful coöperation requires a conciliatory spirit, which is ready to see the other man's point of view and if necessary to make concessions.

Industrial coöperation may be illustrated by reference to an athletic team, in which complete coöperation is required of all the members. What chance would a school have of turning out a winning team, the members of which lacked the above qualities? " Team play " is the harmonious working together of the different individuals for a common end; and this is coöperation.

Industrial evolution is characterized by increasing coöperation. — Economists usually distinguish four stages of industrial evolution; namely, (1) the family or household system, (2) the gild or handicraft system, (3) the domestic system or house industry, and (4) the factory system. In the first stage there is no separate group of industrial workers, as distinguished from the agriculturalists, but all the members of the group provide for their own wants; there is little separation of functions and practically no outside market. The gild stage is marked by the emergence of a separate group of craftsmen, who, although they may cultivate a small plot of ground, devote themselves primarily to industry, as weavers, smiths, and others. There is a small local market, but the craftsman produces for the most part only goods which are ordered by the customers; as yet there are no intermediaries between producer and consumer. The domestic system is marked by the appearance of commercial middlemen, who buy the raw material, give it out to the domestic workers to be worked up in their households, and sell the finished goods to retailers or perhaps to the consumers themselves. A wider market has now appeared and with it a growing specialization, greater interdependence between the groups, and the necessity for coördinating the separate elements. Finally, the factory stage sees the introduction of expensive machinery, production for a world market, far-reaching division of labor, and the advent of a group of organizers who bring together the various factors of production and direct the various processes.

From even this brief description, it is evident that our industrial development has been characterized by the steady growth of specialization and exchange, and, with this, of coöperation. As society has grown more complex and its component parts more diverse, it has at the same time been knit more closely together by the resulting interdependence, and has become more truly coöperative. " The peculiar characteristic of civilized beings is the capacity of coöperation," wrote John Stuart Mill; " and this tends to improve by practice, and becomes capable of assuming a constantly wider sphere of action."

The present system is one of individual exchange-coöperation. — " The actual economic system of most civilized countries," says Professor F. M. Taylor,[3] " is one in which the coöperation involved, instead of being organized, conscious, is rather *spontaneous, automatic — effected and regulated through free exchange* between individuals or non-political groups. This system we shall call one of Individual Exchange-Coöperation." In the present and following paragraphs, this name and the accompanying explanation will be borrowed from Professor Taylor.

It is probably unnecessary to emphasize further at this point that the present industrial order is genuinely coöperative. It is desirable, however, to emphasize the fact that this coöperation is largely spontaneous and automatic; that is to say, it is not enforced by any superior authority or even by mutual agreement among the various coöperators. It occurs from the spontaneous action of individuals seeking their own self-interest and is carried out through a process of free exchange of the products and services of each with all other producers.

Exchange is therefore the method by which coöperation is effected and regulated, and price is the regulatory agent. If too much of one thing is produced, the price of that article falls and warning is thereby served upon the producers of that article that production must be curtailed. On the other hand, if too little of

[3] F. M. Taylor, *Principles of Economics* (New York, 1921), p. 17.

anything is produced the price rises, the hope of additional profits brings about an expansion of that industry, and the demand is met. Similarly, a scarcity of some article, like wheat or cotton, is immediately reflected in higher prices and consumption is thereby reduced; an equilibrium is thus established between demand and supply. During the World War the government sometimes used its authority to insure the production of needed supplies or the curtailment of consumption of some unnecessary luxury, but in ordinary times no such action is necessary. The necessary adjustments are effected through exchange by the automatic movements of prices.

The final feature of our present industrial system is individual initiative; indeed, the existing order is often called individualistic, because this aspect is so important and differentiates it so sharply from other possible economic systems such as socialism. Under socialism the authority of the government or of society as a whole might determine the distribution of the labor force, the amount of production of different commodities, the ratios at which they would be exchanged against one another — in short, all the economic activities of the members of the society. Under the system of individualism, however, the initiation of most business enterprises and of his own activities rests with the individual. The motive presented to the individual is generally his own self-interest, and while this does not always lead to the best social results yet it does result in keeping the machinery at work.

Coöperation through law. — It must not be supposed, from what has just been said, that every man is wholly free and untrammelled in his actions. We live together in organized communities in which the law requires a considerable amount of coöperation. Streets are cleaned by joint coöperation of all the citizens acting through the city council and the street-cleaning department. The use of the streets is regulated for the good of all, and the good coöperator will be alert to obey the traffic signals. Public parks are a common possession, and the signs requesting the public to " keep off the grass " or " do not pick the flowers " are exhortations asking for fair coöperative use of the privileges.

The same principle exists in the industrial world. The individual workman, who performs some specialized task in a factory, is coöperating with many other workmen, all of whom must obey some directing authority. Team-work is necessary, not go-as-youplease. This may be called coöperation by authority, just as that previously described may be called coöperation by law.

Coöperation is not equal in all parts of the industrial organism. — It is evident that, while coöperation pervades social activities at every stage, it is less powerful in some stages than in others. Any ordinary business, such as a factory, a mine, a store, exhibits a high degree of coöperation and of harmonious adjustment of the different parts within itself. When we pass to the larger trade group composed of different plants which together produce some finished commodity, or even to a group of allied trades, we still find a considerable degree of integration and of coöperative activity. While each part is independent, yet they all work together for a common end with comparatively little friction considering the intricacy of the industrial mechanism. But the smoothness of operation which characterizes the organization of the single plant is lacking. Sometimes mistakes are made; too much of one or too little of another product is turned out, costs are miscalculated, waste occurs, and sometimes one or more branches of the trade stop entirely. It is evident that as the magnitude of the operations and the number of separate parts of the industrial organization increase, the coöperation is less perfect.

This is shown even more clearly when we turn to the national or to the world economy. Although the modern price and exchange system does result in a remarkable degree of coöperation and of territorial specialization, yet the possibilities of disharmonies and of maladjustments are manifestly greater than in the single plant or even in the group of allied trades. There is lacking any single directing will to organize the various parts into a smoothly working whole. Mistakes in production are more frequent, misunderstandings occur more easily, and the different parts often work at cross-purposes, as in the case of retaliatory tariffs. The world economy is a mechanism which is as yet but rudely constructed, which creaks and groans as it operates, and which not infrequently breaks down. In the recent World War it was completely disorganized.

In this fact of the lessening of conscious coöperation and of harmonious adjustment as we pass from the economy of a single plant to that of the world is to be found an explanation of the continuous efforts to bring industry into closer organizations by means of large corporations and trusts. This is an attempt to substitute complete unity of purpose for the less complete coöperation achieved through our system of individual competitive enterprise. In some cases this unity is attained by governmental action, as by government ownership of the telegraph system or of the post office; sometimes it is sought by government control, as in the case of the railroads in the United States.

Further coöperation is practicable. — The growth of the trust movement shows to what an extent coöperative, organized effort is taking the place of competition between different plants or companies. The conduct of the World War proved that coöperation is possible even between nations. There was in the first place a unified control of the Allied armies and also of those of the Central Powers. Coöperation was successfully carried out in the field of shipping through the Allied Maritime Transport Council; in financial matters through the Allied Credit Control; and in commercial matters through the Allied Food Control and various committees for handling raw materials. " The war in fact demonstrated," wrote W. S. Culbertson,[4] " not only that the world needs, but that it is practicable to have, regulating forces more effective than those of unrestricted competition. It has proved that the operation of so-called natural laws can be and should be controlled and directed by man-made organizations. Production can be energized and made to serve a social purpose. Raw materials and food can be distributed where they are most needed. Finances can be controlled and shipping directed. Out of the ruins of the war must come a practical, definite step toward international control, which, as our experience extends and the democracies become better informed, should gradually develop into a League of Nations directing the economic forces of the world in the interests of peace and order."

SUGGESTIVE QUESTIONS

1. Distinguish between the use of the term coöperation in this chapter and its popular use.
2. Describe the coöperation which was involved in providing you with your breakfast.
3. You sometimes hear the statement that a certain successful man is a " self-made man." Do you think that any one is self-made?
4. Find out what nationalities of people possess to the largest degree the qualities necessary for successful coöperative effort.

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[4] *Commercial Policy in War Time and After* (New York, 1919), p. 352.

5. Explain more fully what is meant by "team play."

6. To-day, man competes yet coöperates with his fellow men. What is the meaning of this statement?

7. Does increasing coöperation make one more dependent or less dependent upon his fellow men?

8. Explain how you, as a student, are coöperating with the other classes of people in industry.

9. Name the factors which will probably determine your choice of an occupation when you graduate. Will a conscious purpose to coöperate with your fellow men probably influence your choice?

10. Name some rules by which coöperation in a school or college is obtained.

11. Why do the majority of people work for an employer rather than manage a business of their own?

12. Is the need for international economic coöperation an argument against war?

13. What is the directing force of coöperative effort?

CHAPTER VII

THE ORGANIZATION OF MODERN INDUSTRY

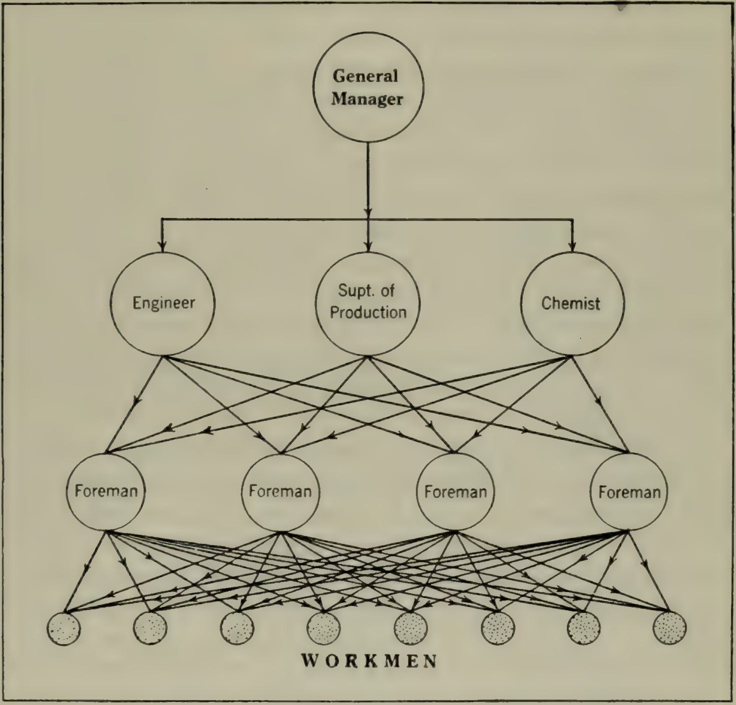
Production by specialists must be coördinated. — In our study thus far we have seen that specialization means the performance of only a fractional part of the work of producing finished goods on the part of each individual or factory. It therefore becomes necessary to link up these separate operations and processes into one related whole. This coördination of specialists is itself a specialty; it is the task of business organization. The success of the industrial coöperation described in the last chapter depends in large measure upon the ability and success of the men who are to act as business organizers. It is therefore essential that these men should be well trained and carefully selected. This chapter will endeavor to show how these requirements are met in our modern industrial system.

A simple example will illustrate the task of the business organizer. The work of a school or college is carried on by highly specialized teachers who devote themselves to one or two lines; for them to interrupt their teaching or study by trying to manage and direct the activities of the whole institution would involve a loss in efficiency. Consequently, another specialist is brought in — the principal of the school or the president of the college — whose duty it is to coördinate the work of the various teachers and unify them into an harmonious and smoothly working faculty. The duties of an athletic coach will illustrate the same point. It is quite conceivable that nine or eleven boys could unite to form a team, each one playing according to his own ideas; but it is unlikely that such a team would win any victories. It is the province of a coach to develop the special ability of each player, but even more is it his duty to weld the various players into a unified team, every part of which shall coöperate with the others to a common end. Similar to this is the task of the organizer of modern industry.

How Robinson Crusoe organized his business. — The illustrations just given probably simplify the problem too much. It is true that in a single industrial plant the manager may organize the different workers much as a school superintendent or a college coach organizes his material, but a vastly more complex and difficult problem is presented in the coördination of different plants, situated perhaps in widely separated localities. There is no visible central authority which can control these various units, and it must therefore be effected through some unconscious process. But since the problem presented in business organization is so complex, it will have to be presented first in its simpler aspects.

When Robinson Crusoe landed on his desert island his first problem was how to dispose of his time and labor so as to provide himself with the things he needed most. He had no one to consult and was the sole determiner both of his needs and of the use of his time in satisfying them. And yet even he had to meet the problem of priority; since he had only his own strength and a limited supply of capital or tools he could not do everything at once and had to choose the most important and forego others. Thus when he started to bring supplies off the wrecked ship he wrote: " Having considered well what I most wanted I first got three of the seamen's chests and lowered them down upon my raft; the first of these I filled with provisions; after long searching I found out the carpenter's chest, which was, indeed, a very useful prize to me, and much more valuable than a ship's lading of gold would have been at that time. I got it down to my raft. My next care was for some ammunition and arms." And after he had landed all the articles which he could salvage from the wreck, he had to decide how to meet his subsequent wants; first came the digging of his cave, then the fashioning of a table and chair, and other things in the order of their importance. Thus he solved the problem of the best apportionment of his resources and his labor.

Organization to-day of the productive factors. — A farmer who owns his farm and has sufficient capital with which to operate it, controls the land, the capital, and the labor in his business, and is at the same time the business organizer. He has to decide whether to leave part of his farm in meadow or bring it under cultivation, whether to plant this crop or that, whether to purchase more fertilizer or to invest in a new tractor, whether to sell his corn or use it to fatten hogs. In other words, he must so apportion his land, his capital, and his labor as to yield him the largest returns. In a simpler state of society, most industries were carried on by small capitalists in their own establishments. To-day, however, the productive factors, namely, the land, labor, and capital, required for the carrying on of a business are generally owned by different persons. In our modern industrial society there is a large class of persons who supply labor and nothing else. Others supply capital; usually this is done by banks which collect the small capitals of many depositors and lend these for business undertakings. Still another group may provide the necessary land.



FUNCTIONAL FORM OF INDUSTRIAL CONTROL

This diagram shows the functional form of organization in which the responsibility for different functions is centered in experts, and passes from them through foremen to the workers.

The necessity of bringing together in a single enterprise these various factors has called into existence a separate, specialized class of business organizers or enterprisers, as they are commonly called. In our modern complex industry the employer or enterpriser occupies a most important position, for upon him depends the successful coördination or linking up of the other factors of production. He decides what shall be produced and how it shall be produced. He hires the workmen, borrows the capital, and rents the land, assuming all the risks of the enterprise and paying the others wages, interest, and rent. On his good judgment and business ability depend not merely his own profits but the best social uses of society's resources.

Production through individual initiative. — His problem is not dissimilar from that which confronted Robinson Crusoe. Society as a whole has a vast variety of wants, but the resources at our command will not permit the immediate satisfaction of all of them; consequently the enterpriser must determine, as did Crusoe, the best apportionment of his resources. During the World War, in order to insure the production of munitions and other commodities needed for the war, priorities for raw materials and labor and even credit were granted to certain manufacturers and an artificial apportionment was thus made. In times of peace, however, there is no such external authority and the enterpriser must use his own judgment.

As Crusoe decided what he wanted most and then produced that, so the enterpriser has to judge what society wishes most. What test or standard shall he use to assist him? A very reliable test exists in the prices which people are willing to pay for goods. If the demand is strong, that is, if many people wish a particular thing, then the price goes up and an inducement is provided the enterprisers to direct labor and capital and land into the production of that article. On the other hand, if fewer people wish an article, that is if demand falls off and the price goes down, the enterprisers will withdraw labor and capital and land from the production of this undesired article.

Qualities of a good enterpriser. — From what has just been said it is clear that the motive which guides the enterpriser is that of profits or personal gain, and these he obtains by his work as organizer. It must be observed that the enterpriser performs a distinct service as organizer, distinct from the contribution of the laborer or the capitalist or the landlord. He may work with his hands, invest some of his own capital in the business, and own the land on which the factory stands, but he obtains profits because of his managerial ability. Since he is placed in such a responsible position, in command of our social resources, it is essential that he should have the qualities of a leader. He must have energy and initiative, judgment and self-confidence, and he must be able to command the confidence and loyalty of others; but above all he must have organizing ability. That is to say he must be able to combine the factors of production in an effective way for the production of commodities which the consuming public wants. If he is a poor organizer and makes mistakes there is a serious waste of our social resources.

Selection of enterprisers. — The description just given presents fairly our individualistic, competitive society as it works under the guidance of our industrial enterprisers. It would seem, from the importance of their work that they should be chosen very carefully. But here is a remarkable aspect of modern industry. These organizers, upon whom the proper functioning of business depends, are self-appointed. Practically any one can set up in business for himself and become an enterpriser. And as a matter of fact thousands of men every year attempt to do this; of whom a few show the requisite ability and the rest fail. How many there are of the latter group the statistics of business failures testify. In 1917, there were 205,000 corporations in the United States. Of these 100,000 reported no net income whatever; 90,000 made profits of less than $5,000 a year; and only 60,000, or one-quarter of this whole number, reported profits of $5,000 a year or more.

Just as in the physical world, so also in the world of industry, there is going on a competitive struggle. Different individuals are competing with one another; the more able succeeds and forges ahead, while the less able lags behind in the industrial race. Enterprisers are constantly experimenting with new methods and processes, new inventions are made and new machines utilized, and new products are manufactured and placed upon the market. In every instance there is a competitive struggle between the old established method or product and the new one which tries to displace it, as a result of which the better succeeds and the poorer is eliminated. This same struggle takes place between the enterprisers or business organizers themselves, and is the process by which the incapable and unfit business men are retired to the ranks after they have shown their incapacity for leadership. This competition is a very wasteful method of determining who are the efficient organizers, for the unfit may waste a great deal of capital and effort in misdirected production. Fortunately, however, the necessity of obtaining the coöperation of other men, and persuading them to entrust their capital or land or time to the control and direction of an enterpriser, prevents the grossly unfit from attaining a position of leadership. It is a method of " trial and error," and, wasteful as it undoubtedly is, does succeed in placing our business enterprises under the direction of probably the most competent men.

The present system of industry is organized. — The socialists are fond of criticizing what they call the " planlessness " and " chaos " of the present competitive system. It is clear, however, from what has been said — and this will be made still clearer in subsequent chapters of this book — that our present industrial system is highly, and on the whole efficiently, organized. It is certainly not planless, for modern industry is carried on for very definite ends; nor is it chaotic, for then it would be in a condition of utter confusion and disorder. Now whatever other characteristics our present industrial system may have — " scramble for wealth," " suicidal competition," or whatnot — it is undoubtedly a workable system, marked by order and plan. It is worth while to quote on this point the words of an able English writer: [1]

" Imagine a committee of the Economics Section of the Saturnian Association for the Advancement of Science reporting on what they had been able to see of affairs on our planet through a gigantic telescope big enough for them to see human beings moving on its face. Would they be likely to report that poor Mundus seemed quite chaotic? Would they report that everyone was scrambling for himself to the disadvantage of everyone else in such a way that the general good seemed entirely neglected? Would they say that all the land in the most convenient situation was lying idle, that nobody had a roof over his head, and that everyone was running about aimlessly or sitting idle in imminent danger of starvation? They might report something of this kind if they could carry on a conversation with certain people here and believed all they were told, but certainly not if they judged by their own observation.

" They would be much more likely to report that they had seen a very orderly people coöperating on the whole with a wonderful absence of friction — that they had seen them come out of their homes in the morning in successive batches and wend their way by all sorts of means of locomotion to innumerable different kinds of work, all of which seemed to fit somehow into each other so that as a whole the vast population seemed to get fed, and clothed, and sheltered. They would not, of course, vouch for the perfection of the arrangements. They would see that there were occasional irregularities and hitches. They might see now and then too many vehicles in one street, too many passengers trying to travel by one train or tramcar. They might even see along our roads the melancholy spectacle of men tramping in both directions evidently in search of the same kind of work. They might be able to see that some had too much — more than they seemed to know how to dispose of without hurting themselves and others — while some evidently had too little for healthy and happy existence. But in spite of these defects they would report, I think, that on the whole the machinery, whatever its exact nature, seemed to do its work fairly effectively. And if we can imagine them able to go back five hundred or a thousand years, we can feel tolerably sure that they would report still more favorably, since they would then see that enormous improvement had taken place and would discover no appearance of any change which would suggest that the existing system is not the outcome of an orderly development of the institutions of the past."

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[1] Edwin Cannan: *Wealth* (London, 1914), pp. 73–75.

Waste in industry. — The work of coördination involves two processes, first, that of combining land and labor and capital — the factors of production — in such combinations as to obtain the desired products in the best manner and at the lowest cost; and, second, that of marketing the products at such prices as to obtain a profit. The first is primarily a physical problem and the second is a pecuniary one. Only the former of these comes within the scope of this book; the other constitutes the subject matter of texts dealing with the principles of economics and marketing.

As has been stated, the work of coördination and management of the various factors, and their arrangement in the best order and proportions, is generally well done under our competitive system, but there still exists a great deal of waste. How great this is, even in the industries in which technical efficiency is developed, was not suspected until the publication of the Engineers' Report on "Waste in Industry" in 1921. This was prepared by a committee, appointed by Herbert Hoover, representing the Federated

American Engineering Societies, which investigated 1125 plants in six industries: men's ready-made clothing, building, printing, boots and shoes, metal trades, and textiles. Waste in industry was attributed by this committee to four fundamental causes:

1. Low production caused by faulty management of materials, plant, equipment and men.
2. Interrupted production, caused by idle men, idle materials, idle plants, idle equipment.
3. Restricted production intentionally caused by owners, management or labor.
4. Lost production caused by ill health, physical defects and industrial accidents.

The responsibility for these losses was placed primarily upon management, which, because of conservatism, inertia, or ignorance, did not avail itself of the efficient practices utilized in the best plants in each industry. Specific illustrations were given of the resulting waste. Due to faulty control of deliveries of material there was an average loss from idleness in shoemaking, occasioned by waiting for work and material, of 35 per cent of the time. Faulty planning of the work in clothing factories occasioned an average loss, not including shut-downs, of about one-third. Interrupted production prevented the full utilization of the labor power: on the average the clothing worker worked only 69 per cent of the time; the shoemaker 65 per cent; and the building trade workman 63 per cent. Plants and equipment were also idle: " clothing factories are built 45% larger than is necessary; printing establishments are from 50% to 150% overequipped; the shoe industry has a capacity of 1,750,000 pairs of shoes a day, and produces little more than half that number." Production is sometimes deliberately restricted by owners, to raise prices, or by laborers, to spread out the work or secure for themselves a monopoly. And, finally, much production is lost through preventable sickness or accidents.

These illustrations indicate sufficiently the enormous waste which yearly occurs in industry through failure to adopt scientific methods of production. They also show the important services which an efficient manager can render in the proper organization of his industry so as to prevent wastes of this character, and to obtain better coöperation and coördination.

Forms of business organization. — In the discussion of coöperation in the previous chapter it was pointed out that coöperation became ever less close as we proceeded from a single plant to a group of allied industries and finally to distant regions which exchanged goods with each other. A similar problem is met with as industries expand from single plants to great integrated industries, scattered, it may be, throughout several states. How can the business be organized so as to permit of a unified and harmonious management as it grows in size and complexity? There are several forms of business organization, each of which is fitted for particular types of business. It will be sufficient here to describe the three most important ones.

(1) A *single enterpriser* may control the whole undertaking, doing everything himself, as does a farmer, a retail grocer, etc., or he may be an employer and employ hired workers and borrowed capital. Such a one-man business has many advantages, for the eye of the master is everywhere, he works hard and holds down expenses; but it has the disadvantage that it is unsuitable to a large and complex business. It is best adapted to small-scale, "one-man," enterprises.

(2) The *partnership* overcomes some of these disadvantages, for now two or more men are associated in the conduct of the business. All the partners are equally responsible for the management of the enterprise, and each one is individually liable for all the obligations of the firm or for any contract made by any of the partners in the firm's name. This unlimited liability restricts the use of this form of organization to businesses calling for diverse abilities and small capital, but which have outgrown the single enterpriser type.

(3) The *corporation* is to-day the most important form under which large businesses are organized. It is an association of persons known as stockholders who are authorized by a charter to elect a board of directors and through it to manage a specified business. Corporations usually enjoy perpetual life and may continue the business even though the stockholders change or die; this is not true of either of the other two forms. The liability of the stockholders is usually limited to the actual amount of capital they have invested in the shares of the company; in the other two forms the liability is unlimited. This is an important advantage in an age when enormous amounts of capital must be invested in the ordinary industrial enterprise, for by a limitation of the liability

incurred many small investors are enabled to put their savings into large-scale business.

There are, however, certain disadvantages connected with the corporate form of enterprise. The owners — the stockholders — are no longer the managers, as in the case of the single enterpriser or the partnership; the manager is hired to organize and conduct the business. There is lacking therefore the same vital interest in the success of the business. Owing to the fact also that the stockholders are so numerous and scattered there is a diffusion of responsibility; things may be done by a board of directors or a manager of which the individual stockholder is ignorant and of which he would not approve. But in spite of these and other disadvantages connected with the corporation this form of business organization has proved itself best adapted to large-scale industry, especially where large capital is needed. It is estimated that over half of the total products turned out by all businesses in the United States, including farms, mines, etc., as well as manufactures, are produced by corporations.

In the management of these great corporations, sometimes with a capital of $1,000,000,000, the talents of the ablest organizers are required. In order to attract ability of a sufficiently high order enormous salaries are paid. And yet there is always complaint of the dearth of men who can measure up to the requirements of these high positions.

SUGGESTIVE QUESTIONS

1. Describe in detail the functions of a business organizer or enterpriser.

2. What useful services are performed by a floor walker in a department store? By a foreman in a factory? By a school superintendent?

3. In contrasting the position of Robinson Crusoe, alone on his island, with that of the average worker in your community, what single point of difference worked most to the disadvantage of Crusoe?

4. In what fields has the small scale, one-man type of business been able to maintain itself?

5. " If the wheat crop of the world should fall off one-half next year, a rise in price would then be of great social advantage." Explain this statement.

6. Does the saying, " There is always room at the top," mean as much to the workman of to-day as it did to those of seventy-five years ago?

7. What is meant by the statement that enterprisers are self-appointed?

8. How do you account for the large number of business failures which occur every year?

9. Why are the managers of industry paid such high wages? Do you think that they earn them?

10. Which is the better way to obtain economic progress — to overthrow the present industrial system and supplant it with another, or to try to remedy the defects while retaining the good features of the existing system?

11. Name some specific cases of waste in industry which have come to your knowledge.

12. Why are the productive factors in a business ordinarily not all owned by a single individual?

13. What are the principal reasons for the adoption of the corporate form of business organization?

PART II

MAN AS A CONTRIBUTING AGENT

CHAPTER VIII

THE HUMAN FACTOR IN INDUSTRY

Man and Nature. — In the drama of man's unceasing struggle for existence and later for a higher standard of living there are two main factors, man and nature. The great differences which exist between different countries of the world in material civilization may always be explained in terms of the character of the people or of the natural environment in which they live. The prosperity of the people in the United States is due either to their own abilities as producers, or to the favorable natural conditions under which they live, or to a combination of both factors. And if Americans enjoy a higher standard of living than say Arabs, the explanation must be found either in the personal qualities or the environment of the two peoples. Before undertaking to describe his industrial achievements, therefore, it will be necessary to study the influences which make man an efficient worker, and to this inquiry Part II of the book will be devoted. In the next place, a short survey may profitably be made of the physical world under whose conditions man produces, and with this Part III will be concerned. The knowledge thus gained of man and nature will enable us to understand better the limitations and achievements of modern industry.

Classification of different kinds of labor. — It has been said that the characteristics which differentiate man from the animals and constitute him man are reason and the human hand. Animals perform certain acts to satisfy the needs of their existence, but with them the effort is largely instinctive; man alone performs deliberate and purposeful acts to achieve his ends. As man has progressed his mental faculties have become increasingly more important than his manual skill, but both are involved in varying degrees in economic labor.

By economic labor is meant human effort, mental or physical, directed to the production of economic goods or utilities which gratify human wants. This may be classified under the following heads: [1]

1. Discovery and invention.
2. Appropriation of the free gifts of nature, as of wild fruits, wild animals, and minerals.
3. Production of food or raw materials, by agriculture, stock raising, and similar occupations.
4. Transformation of raw materials into finished goods, ready for human consumption, by manufacturing.
5. Transportation and distribution of goods to the final consumers by transportation agencies or by wholesale and retail houses. Closely connected with these are the labors of bankers, commission men, insurance agents and similar trades.
6. Personal service, such as the work of domestic servants, actors, firemen, policemen, lawyers, statesmen, physicians, teachers, and of others who produce utilities rather than material goods.

It is obvious that not all individuals nor all groups of people in different parts of the world will perform these activities equally well. It is the purpose of this chapter to describe some of the factors which make man a good worker, and whose presence or absence accounts for the great differences between individuals and nations.

Efficiency of labor. — Assuming a given number of people living in an environment whose resources have been fully developed, it is evident that any increase in the production of wealth will in the main depend upon the increased efficiency of the individual laborers. It is important, therefore, to know upon what this in turn depends. It is impossible to enumerate all the factors which determine a man's efficiency, but the following are some of the more important of those which influence his personal or subjective qualifications. The factors which determine the nature of the materials or tools with which he works, and which affect his efficiency by influencing the conditions under which he works, may be called objective and will be left for later discussion. The subjective factors may be roughly classified into four groups, according as they affect his physical vigor, his intellectual qualities, the attributes of will, or his moral character. No hard-and-fast lines, however, can be drawn between these four groups.

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[1] W. Roscher: *Principles of Political Economy,* Vol. I, p. 137

Physical qualities. — Prominent among the physical qualities of a people are their health, strength and endurance. The original endowment of physical vigor, inherited at birth, differs greatly between individuals within a country and between those in different countries. Into the causes of these differences it is not necessary to inquire here, but something may be said about the conditions necessary to maintain the physical vigor of workers. Among these are food, clothing and housing.

Food is the fuel of the human body, just as coal is of the steam engine, and enough must be provided to replace all waste tissues, to supply force and energy, and to allow for increase in efficiency and well-being. Numerous experiments have been made to determine the exact amount of food calories needed by workers in different pursuits and the proper selection of foods so as to obtain the requisite amounts of proteins, carbohydrates, sugars, starches, and other food values. It would seem the height of folly for any employer to pay his employees wages inadequate to provide them with food sufficient to maintain them at a high stage of efficiency, but such is unhappily the case in many instances. " In England now," wrote Professor Marshall in 1898,[2] " want of food is scarcely ever the direct cause of death; but it is a frequent cause of that general weakening of the system which renders it unable to resist disease; and it is a chief cause of industrial inefficiency." The same statement might be made for every country in Europe, and even for certain industrial groups in some of the larger cities of the United States. And even where the income is sufficient to purchase sufficient food it is sometimes so badly prepared by unskilled housewives that it loses much of its food value, or it is spent for poorly selected articles which lack proper nutritive qualities. For these reasons many social reformers have urged not merely higher wages, but also model kitchens, instruction in cooking in the public schools, temperance, and similar movements.

While clothing is of less importance than food, it should be sufficient, in our frosty climate, to keep the wearer warm. Ill-clad workmen lose bodily heat and energy, suffer from stiffness, rheumatism, and other evils, and are in general less efficient than the well-clothed.

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[2] *Principles of Economics*, 4th edition, p. 275.

Housing is even more important, as it affects health and vitality more broadly. Badly built houses with imperfect drainage lead to disease; insufficient or expensive housing causes over-crowding with consequent physical and moral ills; and the use of cellars or dark rooms is followed by other evils. These evils are especially prevalent in the tenement houses of the crowded districts of our larger cities and many people think that they are inextricably united with city life; they believe therefore, that the movement of population from the country to the city means physical deterioration of the people. If the dangers of bad housing and overcrowding are understood and prevented, no evil results need necessarily follow from living in a city. The improvement in tenement houses, the provision for parks and playgrounds for children, public baths, open-air gymnasiums, and similar methods of insuring at least a minimum of fresh air and breathing spaces for the city population show the lines along which reforms are being pushed.

Intellectual qualities. — Among the mental qualities which help a man to take his place in modern industry and to succeed there may be mentioned the following: intelligence, judgment, imagination, and teachableness. On the value of the first of these qualities President Francis A. Walker expressed himself vigorously.[3]

" Intelligence is a most powerful factor in industrial efficiency. I speak not now of technical knowledge, but of clearness of mind, quickness of apprehension, strength of memory, and the power of consecutive thought, in no more than the degree in which these may be expected to be found in a nation where popular education exists and has existed for generations. The intelligent is more useful than the unintelligent laborer: (a) Because he requires a far shorter apprenticeship; he can learn his trade in a half, a third, or a quarter of the time which the other requires. (b) Because he can do his work with little or no superintendence; he is able to carry instructions in his mind, and to apply them with discretion to the varying conditions of his work. (c) Because he is less wasteful of materials. In some branches of manufacture the value of the materials is equal to the amount paid in wages. In others it is twice, thrice, and even ten times as much. In such branches of manufacture as these, a very little difference in the degree of thoughtfulness, foresight and regard for instructions exercised by the laborer, may make a great difference in the net product; that is, the value of the product after the value of the materials has been deducted. (d) Because he readily learns to use machinery, however delicate or intricate. It is only the intelligent workman who can avail himself of this great help. Brains are not alone required for the invention of machines; they are required for their adjustment, their ordinary use, and their occasional repair.

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[3] *Political Economy*, p. 52.

" The United States is the only country in the world, excepting some of the English colonies, in which it can be safely assumed of the average laborer that, after a reasonable period of experiment and trial, he will be able to use delicate and costly machinery to the advantage of his employer. In all other countries, even the most civilized, it is only picked laborers who can use intricate machinery without doing more damage than their labor is worth."

Judgment is closely allied to intelligence. It is the power to decide wisely among conflicting choices, to determine correctly the merits of different courses of action. More rare than intelligence, it is less apt to be called into play on the part of the ordinary workingman, but is exercised rather by managers and others who decide policies. Imagination is the power of the mind to picture the results of an act, as hunger following laziness, or the connection of the different parts of a machine or enterprise with one another, as between the expansive power of steam and the propulsion of a locomotive. When combined with action it becomes a constructive or creative faculty. In modern industry there is little opportunity for the development of imagination on the part of the worker, but in the handicrafts, in work like designing, in artistic work of all sorts, and in some lines of personal service, there is still scope for it.

Teachableness, or willingness to learn, is akin to imagination. It means open-mindedness, a readiness to accept suggestions from other people, and to adopt their ways if these are proven better than ours. On the whole this quality has been characteristic of the American people, though there are many persons who cling to antiquated methods on the ground that " what was good enough for my father is good enough for me." The more ignorant and backward people are, the less willing they are to give up their traditional customs, and the less teachable they are. Prejudice, superstition, and similar habits of mind constitute obstacles to the acquisition of knowledge or of better ways of doing our work.

Attributes of the will. — This group of qualities involves, in addition to intellectual comprehension, an act of the will, a decision or purpose. It includes industry, diligence, perseverance, punctuality, sobriety, energy, ambition, initiative, self-reliance, and thrift. The will to work depends on a number of factors such as a conscious want to be gratified, some assurance that the laborer will enjoy the fruits of his labor, and a social organization that encourages work. There have been systems of philosophy or religion which preached self-abnegation or simplicity of life, and frowned upon economic activities other than those required to provide the bare necessities of existence. Members of these groups would lack the incentives to work. In the United States, however, and generally throughout Western Europe, and increasingly in other parts of the world, there have been awakened such strong desires for economic goods, that the motive for work is everywhere present.

The qualities mentioned above are of slow growth and exist among different peoples in very unequal degree. Those nations among whom they are most developed are manifestly best fitted for modern industry. Machine industry and the factory system demand such qualities as industry, diligence, perseverance, punctuality, and sobriety. Economic progress and improvement of industrial methods depend upon energy, ambition, initiative, and self-reliance. Capitalistic enterprise calls for the exercise of thrift, or the devotion of present work to the provision for future needs rather than to the gratification of immediate wants. It involves self-control.

These qualities are so common that we are apt to take them for granted and assume that they are universal human traits. A glance at the characteristics of backward peoples will show, however, that this is not the case. Pastoral tribes which have lived a nomadic life, or those which have lived by hunting, find it impossible to adjust themselves to the requirements of civilization. They work by fits and starts; their labor is neither constant nor steady. It is impossible for a man who lacks the qualities enumerated above, to obtain a living in modern industry in competition with steady workmen. But the nature of the savage is not merely inconstant; it is also impulsive and uncontrolled. " A civilized man," writes Francis Galton,[4] " must bear and forbear; he must keep before his mind the claims of the morrow as clearly as those of its passing minute; of the absent, as well as of the present. This is the most trying of the new conditions imposed on man by civilization, and the one that makes it hopeless for any but exceptional natures among savages, to live under them."

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[4] *Hereditary Genius,* p. 336.

Moral qualities. — Important as are physical vigor, mental power, and purpose of will, they need to be supplemented by moral character if the individual worker or nation is to become great and prosperous. Under the head of moral qualities may be listed dependableness, honesty, fidelity, helpfulness, cheerfulness, courage, obedience, and coöperation.

One of the most striking characteristics of modern industry is the interdependence among people in a community or among different communities, and this interdependence is based upon mutual confidence. A society organized on such a basis could not endure unless its members were dependable and reliable. This involves honesty, because we depend upon the promises and the goodness of the wares we purchase of other people; we trust the strength of a bridge or elevator, the purity of the food or medicines, and the soundness of a check given in payment of a bill. Unless we could trust to the honesty of other people in these regards modern industry would break down. Fidelity is the virtue of keeping faith, and is essential in a business world where much work is done upon a contractual basis and which involves future payments. Because an employer can count upon the faithfulness of his employees he may with assurance make contracts for future delivery of goods to his customers.

Cheerfulness, hopefulness, and courage are all helpful industrial virtues. They give evidence of self-respect, social ambition, and capacity for meeting bravely any difficult situation that may arise. People with these qualities will go far in modern industrial life. Finally, the qualities of obedience and coöperation are essential in a society of specialists. No one to-day lives an isolated life nor produces all the goods which he consumes; he is a member of a complicated industrial organization in which each performs a single task, perhaps part of a complex process. He must take his place in the organization, as a worker in a factory or as a switchman on a railroad, or in some other position, but in any place he must be obedient to law, to regulations, and to orders. Similarly he must coöperate willingly with his fellow-workmen. Modern industry can not be carried on by a disorganized mob of individuals; it requires trained and disciplined men who will work harmoniously with their fellows. That this is so generally done with comparatively little friction is a high tribute to the moral character of the workers.

How social conditions affect efficiency. — Thus far only man's personal qualities have been discussed, but it is obvious that many of these are not innate or inborn, but are themselves the product of the social conditions and institutions under which he lives. Man lives and works in an environment which is partly determined by nature and partly by man himself. The family is a human institution which affects very directly man's productive efforts; it is in the family that the child receives his first training in coöperative effort; later, as a man, he in turn becomes responsible for the lives and welfare of his children and has an incentive to work which would otherwise be lacking. The state is the expression of man's efforts so to organize with his fellows as to establish stable and just political conditions for living together. Systems of law are rules of conduct agreed upon by men to regulate their actions and to control anti-social tendencies. Economic institutions, such as personal freedom, private property, competition, inheritance and similar customs, affect profoundly man's willingness to work and therefore his productiveness. It will be possible to mention only a few of the more important conditions, but these will serve to indicate the influence upon the individual of social ideals and customs.

Political institutions. — One of the most important conditions is political security, that is to say the safety and security of the individual and his property from arbitrary seizure, exploitation, or destruction. Government is usually thought of as a safeguard against injustice and disorder, but sometimes the government itself becomes an instrument of extortion or confiscation or overtaxation. This is the greatest form of insecurity, for against a tyrannical government there is no defense. If the property and fruits of work of the laborer are in danger of being torn from him by the powers of government itself there is lacking the very basis of political security. In such abuse of power is to be found one of the explanations of the present poverty of certain parts of Asia, which were once prosperous. On the other hand, the industrial development of the best governed parts of Europe and America may be attributed in part to the security and safety afforded by just and impartial government.

Happily, insecurity due to the rapacity or tyranny of government is unusual in developed industrial states. More frequent is the insecurity and uncertainty due to the disorder, crime, dishonesty, and greed of individuals, who are not restrained by a strong government. To insure productive effort the worker must feel sure that he will enjoy the fruits of his labor; if there is doubt on this point, then one of the great incentives of industry has been removed.

People will not risk their capital and property in a country where political revolutions are frequent, where the administration is corrupt, or where administrative policy changes often. Mexico and most of the Central American countries are rich in natural resources, but their development has been slow because people have been afraid to work or to risk their capital there, due to insecurity and uncertainty. If the people are certain that the State is going to maintain a stable policy regarding property they are willing to put their time and their money into the development of industry. Otherwise the great majority is not willing to do so.

In addition to maintaining stable political conditions, a nation may aid industry positively in other ways: by regulating foreign trade and interstate commerce, by the proper control of freight rates, by factory legislation, by proper banking policies, and by maintaining bureaus and organizations for obtaining and distributing information regarding the different aspects of industry. A nation can, with proper policy regarding these matters, increase industrial efficiency and cause a smoother working of the whole industrial machine; or, with a passive policy dominated by special interests, it can retard development, or develop some industries at the expense of others. If the latter is the case, a nation can never reach the plane to which its productive powers might properly entitle it.

Social institutions. — Important as are political institutions and legal enactments in protecting life and property and insuring the fruits of industry to the producer, even greater safeguards are found in the manners, habits, and customs of the people. Social institutions and arrangements, customary modes of acting and thinking, and codes of morals, on the one hand prevent people from acting in an anti-social way, and on the other place the stamp of approbation upon the approved method. A society in which plunder was the normal and approved way of obtaining wealth, as among certain nomadic Arab tribes, would certainly develop different habits of industry and thrift than one in which every encouragement was given to regular, persevering, and enlightened labor. This is an extreme illustration, but it shows how customs and social ideals may affect the efficiency of the worker.

The social esteem in which labor is held has a profound effect upon the ambition and hope of the laborer and hence upon his energy and efficiency. The feudal organization of society in the Middle Ages, which fixed the place of the worker without any possibility of his rising to any higher position, removed one of the chief incentives to initiative and industry. In the same way the caste system represses hope and ambition and has a deadening effect upon the lower classes. Even more blighting is the influence of slavery where this institution exists. Where labor is despised and degraded its efficiency will be in keeping with the esteem in which it is held. Since the fruits of his labor do not belong to the slave, he will do as little as possible. Slave labor is notably inefficient, reluctant, careless, and wasteful. Under such a system industrial progress is impossible.

The industrial organization. — Some writers, especially the socialists, claim that, although human slavery has been legally abolished, the present wage system as it is in modern industry results in what they call wage slavery. They assert that, while the worker is nominally free, he is nevertheless really under compulsion to work under conditions and for wages which are determined by employers; hunger forces him to work, and so he is compelled to accept the terms offered him or starve. He is thus a wage slave.

It is, however, evident that this is a very distorted view. The earlier chapters of this book have made it clear that modern industry is a coöperative undertaking and that slavery and legal compulsion are not the forces which force men to work. The only compulsion which exists is the appetites and desires of men for economic goods and services. Since there are not enough free goods to go around it is necessary to work, and work hard, to produce the needed supplies of things which men want. All our political and social institutions are antagonistic to slavery. The real question which presents itself is whether the industrial organization of society to-day encourages or suppresses the qualities of good workmanship which have been described.

In the first place there must be a proper incentive to work. This incentive may be found either in the pleasure and satisfaction derived from the work itself or in the money reward which is received for the work. In modern industry the latter is the universal and almost the sole incentive which is offered. A few fortunate workers, such as the writer, the artist, the craftsman, derive satisfaction from the performance of the work itself, but this is not the case with the factory worker. The mediæval craftsman, who produced a complete article, took a pride in efficient workmanship and a good reputation, but the modern machine operator, turning out the eighteenth part of a pin on an automatic machine, can not be expected to feel any creative joy in his work. Some writers, magnifying the significance of this aspect of mediæval craftsmanship, would turn the hands of the industrial clock back, abolish machinery, and reintroduce creative hand labor. The path of industrial progress does not lie in this direction, however, for this would mean the sacrifice of most of our material well-being. Rather, the solution seems to lie in making the conditions of work as pleasant and comfortable as possible, and in assuring to the worker a reward so liberal that it will overcome his normal reluctance to work. The former of these conditions is being met increasingly by the more enlightened and progressive employers. The latter is a problem which belongs to more advanced courses in economics, but even an elementary survey makes it clear that only by increased productivity can larger incomes be obtained.

The second condition which the industrial organization should maintain, if these incentives are to operate effectively, is opportunity. It is a fair question then whether the present industrial organization offers every man a fair chance to develop himself and to find the proper niche for himself in the social system. The system of universal, free, and compulsory education is the first step towards preparing children for life, and vocational training is an effort to develop the peculiar abilities of boys and girls along particular lines. Differences in the degree of success in life is due partly to lack of equal opportunity. Moreover, the system of modern industry gives full scope to the individual powers of self-reliance, independence, and freedom of choice. No man is guaranteed a living, or a fortune, but the industrial organization is designed to permit every man to obtain these with as little interference or obstruction as possible from political, social, or economic institutions.

SUGGESTIVE QUESTIONS

1. Which is the more important factor in progress, the people or the environment? Give examples to prove your answer.
2. Do you know of any cases where animals make provision for the future?
3. Upon what must increased production in the United States depend in the future?
4. Which of the four groups of subjective factors determining man's efficiency do you consider most important?
5. Do any qualities stand out as especially characteristic in the case of successful men? Within that group, which single quality seems most important?
6. Is there any relationship between the efficiency of a worker and the extent to which he is well nourished? Of a student?
7. Find out and report on the housing conditions that exist in a tenement district with which you are familiar.
8. Are country people more healthy than those of the city? What did the physical examination of soldiers for the World War reveal in this respect?
9. Why does foreign industry hesitate to enter Mexico and Central America?
10. Is there such a thing as an instinct of workmanship?
11. Does everyone have an equal opportunity in starting life, or are some placed under a handicap from the beginning?
12. Do you think that there are individuals among the working classes, who are as capable as some high salaried managers and capitalists? If so, what has prevented their advancement?
13. What arguments do you find in this chapter for a good education? For moral behavior?
14. Do you think the following quotation from Gray's " Elegy in a Country Churchyard " has any industrial significance?

" Full many a rose is born to blush unseen,
And waste its fragrance on the desert air;
Full many a gem, of purest ray serene,
Is lost to view in ocean's caverns bare."

BIBLIOGRAPHICAL NOTE

For references on this chapter the reader must be referred to the general bibliographical note at the end of Chapter I. In some of the books on the principles of economics chapters will be found which treat the subject of labor or man as a factor in production, but usually in a brief and inadequate manner.

CHAPTER IX

NATURE AND TRAINING OF MAN'S ABILITIES

The capacity of peoples. — Very slight observation is sufficient to show that the people inhabiting various regions of the world differ widely in temperament and capacity, and that the industrial systems developed by these peoples and the kinds of goods produced by them also differ greatly. Why do these differences exist? The complete answer to this question must be sought in several sciences, such as anthropology or the study of man, ethnology or the study of the races of man, geography or the study of the surface of the earth with its peoples and products, and economics or the study of the production, distribution, and consumption of wealth. In this chapter only those factors will be considered which determine the capacity of a people to take its place in the world as an industrial nation.

Racial differences. — The testimony of travelers, of employers, and of anthropologists seems to be fairly unanimous that variations exist among different peoples and racial groups throughout the earth. Since the economic differences only are of interest in this book, the testimony of economists rather than of other observers will be presented. First a statement by the German economist, Wilhelm Roscher, writing in 1854, may be quoted:

" According to English manufacturers, an English laborer accomplishes almost as much again as a French one, and the latter in turn more than an Irishman. An English contractor, who had worked in French manufactories, expressed his opinion concerning the French to this effect: ' It cannot be called work they do; it is only looking at it and wishing it done.' Thus, for instance, a good English spinner with a machine of 800 spindles could produce 66 lbs. of yarn, No. 40, while a Frenchman could produce only 48 lbs. . . . A Berlin wood-sawyer accomplished as much in ten days as a West Prussian in twenty-seven days. English farmers on the Hellespont prefer to pay Greek laborers £10 per year besides their keep, rather than £3 to Turkish laborers. The Malayan agricultural laborer receives \$2½ per month, the Malabar \$4, the Chinese \$6."

The American economist, Francis A. Walker, writing in 1884, offered similar testimony:

" Industrial operations conducted upon a large scale have shown that wide differences exist in the working power of men of different nations. In comparing the cost of constructing railroads in India and in England, for instance, it was found that, though the Indian laborer received but 4½ to 6d. a day, and the English laborer, 3s. to 3s. 6d., the sub-contracts in the two countries were let at the same prices. As between England and Russia, it is found that a weaver in the former country tends from two to three times as many looms as in the latter, the English looms moving, moreover, at a higher rate of speed. As between England and France, the superiority of the labor of the former country has been repeatedly shown in great competitive experiments. Mr. Brassey states that, in the construction of certain French railways, it was found that the working capacity of the Englishman was to that of the Frenchman as five to three. Superior as are the workmen of England to those of other countries of Europe, they are, in turn, surpassed, on the average, by those of the United States, in the respects of strength, intelligent direction of force, and ability to use machinery to advantage."

Finally, evidence from another American authority,[1] writing in 1926, may be offered:

" The amount accomplished by the average person varies enormously from region to region. In Japan the average coal miner gets out 1400 pounds of coal per day, in the United States 8800. In Shanghai, where Chinese labor is at its best, it frequently takes a carpenter and a boy a day to put a lock on a door, and then it is not well fitted. In America, with a rabbeting machine, an ordinary carpenter puts on a dozen locks. Even with a chisel and hammer, much like the Chinese tools, an average American carpenter can fit 5 or 6 locks in a day. Again, in Shanghai, a mason usually lays only about 300 bricks in an eight-hour day; in the northern United States, with almost the same tools, and with similar plain work without cornices and other difficulties he is expected to lay 1500."

Theories of racial differences. — There is presented in the preceding paragraphs unimpeachable evidence as to the existence of wide variations in the productivity of workers from different countries. To what causes may these differences be attributed? The explanation of these differences is not to be found in the natural resources nor in the machinery and capital with which the workers are equipped, for even when they work with similar materials and machines they exhibit striking differences in efficiency. It is to be sought rather in the differences in the workers themselves. But why these differences? There are two leading views which attempt to explain the formation of individual character. One school of writers tells us that it depends upon a natural endowment or innate bias which has been derived from ancestors by what is called heredity. The other school insists that it is the result of the environment or the circumstances under which the individual has been reared.

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[1] E. Huntington and F. E. Williams: *Business Geography*. 2nd ed., rewritten (New York, 1926), p. 79.

The first school insists that a certain racial group, like the Nordics or the Latins or it may be the yellow race — according to the birthplace and bias of the writer — possesses a certain innate superiority which makes it the leader among the peoples of the earth. Wherever these people are found they will display their superiority in competition with other races, and to them belongs the dominance of the earth. The other school of writers accepts the political dictum of our colonial ancestors that "all men are created free and equal," and insists that the explanation of existing inequalities is to be found in the differences of the environments in which the various peoples have been reared. The truth is to be found, however, in the extreme views of neither school; rather it must be sought in the middle ground between these two extremes, and due allowance must be given to each of the factors of heredity and environment.

Heredity. — For the purposes of this book it is not necessary to attempt to explain in detail the phenomenon of heredity. The cause of heredity is still as inexplicable as is the cause of gravitation, but the one exists no less truly than the other, and the effects of both can be accurately described.

The first factor to be noted is variability. Offspring usually differ from their parents and from other members of the family. Some of these variations make for success — success in obtaining food, in conquering or escaping enemies, in securing mates, and in other ways. Individuals which develop favorable variation will succeed, while those which vary in the opposite direction will perish leaving no record of their existence. In the course of time the race or stock will consist only of those individuals with the favorable characteristics, and these will become permanently hereditable. The hereditary qualities with which man, or indeed any other animal, is endowed, are the results of innumerable small changes accumulating generation after generation in the same direction. Thus the white race has developed intellectual qualities superior to the black race, but the Negro can resist malaria, yellow fever, and hookworm much better than the white. In each case natural selection has perpetuated in the struggle for existence those qualities which favored the survival of the individuals possessing them.

" Heredity is the relation of organic continuity between successive generations, the living on of the past in the present, the flesh and blood linkage between an individual and his forbears on the one hand, his offspring on the other. . . . Heredity is the reproductive relation which secures that like *tends* to beget like, and yet seldom does. . . . What are called variations and mutations in biological language are the organism's experiment in self-expression, and these are the raw materials of progress. . . . The variations or novelties are the qualities to be tested; the struggle for existence, which includes the organism's endeavors, is the sieve that tests; *heredity secures the holding fast of what has proved good.*" [2]

It is probably unnecessary to add at this point that mental capacity can be inherited as truly as physical characteristics, and that the human race is as subject to the principles of variation, selection, and heredity as are other forms of life.

Eugenics. — Some writers, fixing their attention on the facts of heredity, insist that the only method by which the human race can be improved is by the increase of those racial groups having the most desirable characteristics. Their fear that the reverse process is taking place finds expression in such slogans as " the yellow peril," " the rising tide of color," etc., which suggest that the white race is gradually being submerged by the increasing numbers of other groups which they consider less desirable. With this aspect of the race problem it is not possible to deal here.

Other writers, noting the immense differences between individuals within the same racial group, urge that more attention should be given to questions of human breeding in order that the racial quality should be improved and the most desirable characteristics be transmitted to future generations. Eugenics is the name given to the new science which studies the factors tending to injure or improve the inherited qualities of subsequent generations; as its name implies it emphasizes those influences which favor the birth of those inheriting good qualities, and opposes the reproduction of the unfit. It urges that a stronger and fitter society will result if those who are born shall be physically and mentally sound, rather than by the mere growth in numbers without regard to quality of body or mind.

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[2] J. A. Thompson (Ed.), *The Outline of Science* (New York, 1922), II, 369.

Many extreme and impracticable proposals have been made in the name of eugenics, but it seems clear that the qualitative problem of population is one which concerns society as a whole. So far as possible the development of a better type of human beings should be encouraged, and the reproduction of undesirable types prevented. The laws of heredity are now well understood, and some day society may decide to make practical application of this knowledge by preventing the reproduction of the physically diseased, the mentally defective, and the congenital criminals. Just as, by careful selection and breeding, it is practicable to develop superior types of horses or cattle, it should be possible to produce a highly gifted race of men by judicious marriages during several consecutive generations. A step in the direction of improving hereditary qualities by more careful selection of the racial stock has been taken in the United States by restricting the immigration of peoples thought to possess the less desirable characteristics.

Influence of environment and training. — Although the biologists and anthropologists are not agreed among themselves as to the relative influence exercised by heredity and environment in the make-up of an individual or race, yet we may safely insist that environment and training are important. Certain qualities are given by racial endowment, but if they are to develop to the highest degree possible, the environment must be favorable. By this is meant not merely climate and natural resources, but also the social environment, such as institutions making for thrift and industry, for the accumulation of wealth and raising the standard of living, for law-observance and honesty, for the maintenance of high standards of literature and art and music, for a fine family life, and other similar things. People brought up in the midst of a society holding such ideals conform to them and endeavor to promote them.

Training is of even greater importance, for this is an active agency in the development of those qualities which are thought desirable. Agencies for this purpose are the family, the school, the church, the club, the newspaper, the factory, shop, and mill. Sometimes, as in the school or college, the training is carefully directed to produce certain desired results, and sometimes, as in the case of the newspaper, it is more or less haphazard. But it is evident that good racial qualities can be developed, and bad ones suppressed, by proper training. On the other hand, it cannot accomplish the impossible and produce out of poor racial stock the inventors and leaders of the next generation. A safe rule seems to be that every effort should be made to create as favorable a physical and social environment as possible, and to train the members of a given society to the highest development of their natural powers.

Effects of environment. — By the school of writers who emphasize the importance of environment, the argument is carried even further. According to certain of them, of whom T. H. Buckle may be taken as a spokesman, physical or geographical surroundings determine in large measure the physical, mental, moral, and social qualities of man. Many qualities which have come to be looked upon as hereditary in a race of people, may, if we trace the history of that race and know its early struggle for existence, be shown to be due to the geographical surroundings amid which that race developed. Further, they say, this environment influences man in his economic activities. The physical characteristics and resources of a region determine the occupations of its inhabitants, and the nature of this struggle for existence leaves its impress upon the whole life of a people. They exert a great influence not only upon the character of the political, economic, and social institutions, but also on the development of literature, music, art, and religion.

The services of environment. — Man's environment is a source of food and raw materials, a supplier of power either from animals or from natural forces, and a teacher of industries. The geographic nature of a region and its natural resources determine the occupations and industries of its inhabitants. In New England and Norway, because of poor soil and good fishing grounds, the people early took to the sea. England early became a manufacturing nation because of abundant resources of coal and iron. Desert tribes become nomads and raiders because of the scarcity of other means of livelihood. Environment also determines the position which a nation occupies among other nations. In the first place abundant natural resources are necessary. Then, too, there must exist in a people the energy and ability to utilize these resources in an efficient manner. Energy depends upon the type of climate, whether it be hot or cold; whether uniform or variable; these and other factors being important in stimulating activity and health. Ability may be partly inherited and partly acquired. If inherited it is probably the result of the accumulation of environmental effects over a long period of time. Finally, environment has the characteristic of being capable of improvement in relation to man's wants and the means of satisfying them. Man may modify and improve his surroundings so that they contribute more fully to his well being.

Heredity and environment. — Every human being is a resultant not merely of his inherited qualities, but also of all the influences which mold him during his life. These latter characteristics — often called "acquired" — are impressed from without, and are usually regarded as non-transmissible. By some they are therefore regarded as relatively unimportant. But if these influences are beneficial and yet are not transmitted by heredity, it is all the more necessary to re-impress them upon each successive generation. Moreover, the more favorable environment may stimulate the unfolding of new variations of a useful sort. Belief in the importance of heredity should not lead to a neglect of the factor of environment. A recent writer has stated the relation between these so clearly that it will be worth while to quote from his book on this point at some length: [3]

"The mind, like the body, represents the resultant of two components called Heredity and Environment. These two components jointly determine the character of the man; and they determine it so absolutely that if we were completely informed of every factor in his heredity and environment and if our power of psychological calculation were unlimited, we should be able to prophesy with

[3] Hugh Elliot, *Human Character* (London, 1922), p. 251.

certainty what he would do or what words he would use on any given occasion.

" The question often arises as to whether heredity or environment plays the larger part in the formation of character. The answer depends on what traits of character we are considering. The deeper traits are the product of heredity, and are capable of only small alteration by environment; the shallower traits are mainly acquirements due to environmental influence. Heredity determines the substance of character, but environment is responsible for its external form. It so happens that the shallower differences are often of deep ethical (and industrial) importance. Heredity, for instance, may endow a man with the qualities of genius; environment may decide whether those qualities are exercised to the lasting benefit of society, or in a career of crime. . . . In short, heredity furnishes the mind with its weapons, but it depends largely upon environment to what use they are put."

Modification of environment. — Thus far in this chapter there have been considered those factors making for racial and individual superiority which come from within and which pass by heredity from one generation to the next. But these factors are difficult of change, and the development of new and better variations is the result of a very slow process. It has seemed to many therefore that a more hopeful method of improving the human species is so to modify their environment as to affect beneficially the body, mind, and character of man while they are still in the plastic stage. Modification in the desired direction would thus be impressed upon each successive generation by external influences, and, even though no permanent change should be wrought in the hereditary characteristics, the individuals born and reared in the favorable environment would develop to the full the best characteristics with which nature had endowed them. The remainder of this chapter will therefore be devoted to a consideration of some of these objective influences, which may be summed up under the name environment.

Sanitation and hygiene. — The decline in the death rate is a most encouraging sign of beneficial modification of the environment, indicating as it does a growing mastery over the dread enemy, disease. There has been a steady decline in the death rate in the United States, in those areas where records were kept; this is shown since 1880 in the following table:

Year	*Death rate per 1000 inhabitants*	*Year*	*Death rate per 1000 inhabitants*
1880	19.8	1910	15.0
1890	19.6	1920	13.1
1900	17.6	1924	11.9

The decline in the death rate is ascribable in the first place to the spread of general education in matters connected with health, resulting in better sewage disposal, purer water and foods, saner diet, and more attention to personal hygiene. Better living conditions in general have helped to lower the death rate. Moreover, particular diseases have been practically abolished by the serum treatment; such are smallpox, diphtheria, typhoid, tetanus, and yellow fever. A striking illustration of the advance along this line is furnished by the statistics of disease in the American army. In the Spanish-American War, 20 per cent of all the American soldiers were infected by, and 86 per cent of all deaths were due to, typhoid fever. In the World War between September, 1917, and January, 1918, a period of about the same length, there should have been 150,000 typhoid cases if the same proportion had held; as a matter of fact there were only 114 cases.[4]

The prevention of infection, by better understanding of and control of parasites, has diminished if it has not abolished such diseases as malaria, typhus fever, bubonic plague, hookworm disease, and still others. And finally modern surgery not only prolongs many lives which a generation ago would have been lost, but increases efficiency during life by restorative methods.

Education. — Next in importance to health is education, and here also every effort is being made to improve the quality of our population by developing and training their faculties. Confining our attention to the last fifty years in the United States only, great improvements in both the quantity and the quality of public education may be noted. Some of the more significant statistical data are given in the following table:

	1870	*1922*
No. of pupils enrolled in public schools in U. S.	6,871,522	23,239,227
Percent enrolled of population, 5–17 years of age	57.0	81.2
Total number of teachers	200,515	722,976
Total expenditures for education	$63,396,666	$1,580,671,296
Expenditure per capita of school population, 5–17 years of age	$5.26	$55.26

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[4] E. M. East, *Mankind at the Crossroads* (New York, 1922), p. 225.

There is evidenced here a great expansion in the proportion of children of school age who are being given an education, from 57 to 81 per cent, while the tenfold increase in the per capita expenditures from $5 to $55 may fairly be regarded as proof of an even greater improvement in the quality of that education. Up to the age of five or six the child learns in the home his first lessons in language, in the use of his faculties, and in coöperation. After that age instruction can be given best by trained teachers in well-equipped schools. There is a steady extension in the length of the school term, and the age of compulsory school attendance has been generally fixed at fourteen or fifteen and in some states raised to eighteen. In this way a larger and larger percentage of the children and young people is given the advantages of education, and this is continued to a later period in their lives. They are thus better prepared for life's tasks and are given increasingly specialized training for their particular work. It is possible to obtain under our educational system a training at public expense from the grades through the high schools to graduate and professional colleges. The result of this is to help men to move upward in the economic scale and to develop their particular abilities to the greatest degree. Education may be called a modification of environment designed to stimulate the development of latent favorable characteristics.

Vocational training. — With the growing complexity of modern industry there has arisen a demand that the schools shall do more than give a general education; they are asked to give vocational training which shall fit the pupils to take their proper places, with trained faculties, in the work of the world. As long as industry was carried on by hand, it was usual to apprentice a boy to a skilled artisan by whom he was taught the mysteries of his trade and trained to be a proficient worker. Under modern machine industry the apprenticeship system has broken down. In factories with the division of labor, a man is usually assigned a single operation, so that he never learns the entire process of manufacture; as a specialized worker he is therefore less able to adjust himself to shifts in production or changes in method.

But where is he to obtain this general vocational training, which will give him a better understanding of industry and so develop his faculties that he can choose intelligently the line in which he has the greatest aptitude? It is not to the interest of the factory employer to give his workmen a general industrial training, for he has no assurance that the men whom he has trained will not seek employment in some competitor's establishment; he cannot afford to make the outlay. The burden of giving this general vocational training must therefore be assumed by society as a whole, and must be performed by the schools.

This does not mean that the schools are to be mere adjuncts to the factories or stores, and are to train their pupils in the performance of tasks which they can learn better by actual practice. It means rather that the boys and girls in the public schools are to receive such a well-rounded development that they can make the transition from school to factory or shop, from study to actual work, without loss of time or effort. At the same time they have learned whether they are likely to succeed best as machinists or carpenters, as clerks or farmers, or in the professions. An effort is made not merely to develop and train the latent powers of the younger generations, but also to direct them into lines of activity which will make them better and more useful citizens. In nearly all cities of any size, and in some rural districts, afternoon and evening classes are conducted for adults. Here persons who are employed during the day are given the opportunity to continue their education along lines which will help them most.

In addition to the factors influencing health and education, reference should again be made in this connection to the political and social institutions enumerated in the previous chapter. These, too, help to create a favorable environment for the best development of the individual.

The population of the United States. — From what has been said it seems clear that the different divisions of mankind are unequally equipped by nature with the capacity for industrial progress. The United States is fortunate in having been peopled by the most progressive and energetic races and in large part by the best representatives of these races. The stock from northern Europe, which constitutes the largest group, is generally conceded to be the one best fitted by natural endowment to assume industrial leadership. They possess, in most marked degree, those qualities demanded by modern industry.

It will not do, however, to assume that we as a nation possess any superiority over other nations. Something of a shock to our national complacency followed the publication of the psychological tests made during the World War in the case of hundreds of thousands of soldiers in the United States. These disclosed that the average mental ability of these men was scarcely greater than that of a bright child of about 13 years. They further showed that a majority of the people have not sufficient mental capacity to continue their education beyond the grades, and that not over 12 per cent can profit from a college education. That is to say, the work of invention and of organization, which are all important if the human race is to progress and if we in this country are to get the most out of our environment, must be performed by a comparatively small proportion of the population. It is therefore essential to increase this proportion, to develop the best racial characteristics, and to give our people the best possible training so as to make the most of what we possess. Only thus can the increase of numbers, accompanied by the depletion of our natural resources, be prevented from lowering our standard of living; only thus can we continue to gratify and expand our wants.

SUGGESTIVE QUESTIONS

1. Have you ever noticed differences in the productive efficiency of different workers? How do you explain them?
2. Are there similar differences in the intellectual capacities of the members of the school? What is the explanation of these differences?
3. State, in your own words, what you understand by heredity.
4. Some recent writers have been proclaiming "Nordic superiority." What do they mean?
5. Are any of the following transmissible: Feeble-mindedness? Deafness? Musical ability? Genius?
6. What was T. H. Buckle's theory of the influence of environment upon man's character?
7. If you were trying to develop an improved breed of sheep, would you pay more attention to the factors involving heredity or to those involving environment? Would the same reasoning apply if you were considering an ideal race of men?
8. Name some causes, other than those given in the text, for the lowering of the death rate in the United States. Why is this an advantage from an economic point of view?
9. Does an uneducated person stand as good a chance of success as an educated person? Why is this? Would your answer be the same if you were speaking of colonial days in this country?
10. Have you any idea of the kind of work you will do when you complete your education? Is your decision affected by any of the studies you have had?

BIBLIOGRAPHICAL NOTE

The subjects treated in this chapter have given rise to a mass of controversial literature. The fundamental writings of Darwin, Spencer, Wallace, Lamarck, and Weismann need not be mentioned, as the discussion has moved beyond the statement of first principles. A clear and readable resumé of recent conclusions on the whole subject, although not well organized, is contained in J. A. Thompson (Ed.), *The Outlines of Science* (New York, 1922, 4 Vols.). Among writers who emphasize the importance of heredity may be mentioned F. Galton, *Hereditary Genius* (London, 2nd ed., 1914), C. Pearson, *National Life and Character* (London, 1893), and H. S. Chamberlain, *The Foundation of the Nineteenth Century* (New York, 1912). The innate superiority of the white race has been strongly put by Lothrop Stoddard, *The Rising Tide of Color* (New York, 1920), and by E. M. East, *Mankind at the Crossroads* (New York, 1923). The psychological point of view is emphasized by William MacDougall, *Is America Safe for Democracy?* (New York, 1921), and Hugh Elliot, *Human Character* (London, 1922). One of the earliest and most extreme advocates of the influence of environment was T. H. Buckle, whose *History of Civilization in England* (New York, 1858–62, 2 vols.) still repays reading. A modern writer of this school is Oakesmith.

A fair evaluation of the claims of the two schools is given by E. T. Conklin, *Heredity and Environment in the Development of Man* (New York, 1915). John Dewey, *The School and Society* (Chicago, rev. ed., 1915), states clearly the place of the school in our modern social organization.

CHAPTER X

PSYCHOLOGY AND INDUSTRY

Personal differences. — It was pointed out in the previous chapter that individuals differ, and differ widely, in their inherited traits. They differ in intelligence, in capacity, and in taste, in strength, in health, and in character. These differences show themselves in their aptitudes for their studies in school, for their games and sports, and for the jobs at which they later earn a living. Sometimes the characteristics of a boy are so pronounced, evidencing a bent for music, for the use of mechanical tools, or for business, that it is easy to determine the occupation for which he is best suited. Frequently, the differences are less marked, but nevertheless they exist. In spite of the standardizing influences of home and church and school, which endeavor to enforce conformity to accepted standards upon all members of a society, these differences persist and are carried into manhood. Physical differences, in height, or weight, or strength, are obvious and easily perceived. Now, however, it is coming to be believed that differences in mental qualities are even greater.

These personal differences between individuals are coming to be recognized more and more as vital factors in the industrial efficiency of a people. Modern industry has specialized jobs by the division of labor, but it has lagged behind in the scientific classification of workers according to their peculiar capacities and in the assignment of the right man to the right job. Individuals are differently endowed with qualities of body and mind, and are adapted to different kinds of work. Because of these differences no two persons will succeed equally well in a given task; and because different tasks make varying demands upon the strength or skill or intelligence of the worker, no individual will succeed equally well in two different jobs. Such an adjustment between the worker and his working environment should be made, that the individual will develop his powers most effectively and the work be done better than it could by any other arrangement. This can be termed industrial efficiency.

Hiring and firing. — The methods of selection and placement of workers in most establishments are still unscientific and casual. In general, the practice is to admit applicants, look them over, ask a few general questions, and then hire those who " look good." By such methods even men of experience and training would have difficulty in selecting qualified men or in sending them to the right department or assigning them to the right job. When the hiring and firing are done by a foreman the likelihood of mistakes is enormously increased. Moreover, a man discharged by a foreman seldom gets a chance to make good in another department, although he may be well fitted for that.

An amusing but extreme illustration of the " hire and fire " method is given in the following instance: " One large manufacturing establishment has appointed as monarch of the ' hiring-on window ' a man who had the misfortune to lose a leg in the company's employ. As a consequence of this loss he was given his present life job which he performs to the queen's taste. He was induced to describe his methods and they were somewhat as follows: ' On Mondays I turns down all the men with white collars, on Tuesdays all with blue eyes, Wednesday all with dark eyes. Red-headed men I never hires, and there do be days when I has a grouch and hires every tenth man.' " Exaggerated as this is it brings into sharp relief the evils of this method.

But even when the work of hiring and placement is done by conscientious and careful men who rely solely upon their judgment of the applicant's capabilities as a result of an interview and a few general questions, the results are not satisfactory. Experiments have been made in which a number of managers of plants or departments, who prided themselves on their ability to judge men, have been asked to rank salesmen or mechanics or other workers on the basis of such knowledge. The results showed the greatest variation among the judgments of the managers, and also a wide departure of these from the actual rank of the men as producers. It seems clear that some test, either that of actual trial at work or of some objective measurement of the qualities needed in the work, must be substituted for a superficial judgment based upon a general questioning.

Labor turnover. — The old-fashioned system has meant not only unscientific selection and placement of the workers; it involves also a tremendous labor turnover. By this is meant that there is a steady stream of new men passing through the factory; that there are so many losses and replacements that the newly employed may equal the total labor force in the course of a year. If this is the case the labor " turnover " is said to be 100 per cent. The actual turnover in our industrial establishments ranges from about thirty to several hundred per cent. In 1913 the Goodrich Rubber Company hired within a year twice as many men as were on the payroll at any one time in order to keep the plant fully manned; this was a turnover of 200 per cent. In the same year the Ford Motor Company hired 54,000 new men to keep 13,000 jobs filled — a labor turnover of 400 per cent.

That there was a frightful social waste in such a condition was apparent to every thoughtful person, but not until 1915 was any investigation of this subject published. The study by Mr. M. W. Alexander, head of the training schools of the General Electric Company, was the first attempt to grapple with costs. According to Mr. Alexander there were five distinct elements of cost in hiring and training new employes. These were:

1. Clerical work in connection with the hiring process.
2. Instruction of new employes by foremen and assistants.
3. Increased wear and tear of machinery and tools by new employes.
4. Reduced rate of production during early period of employment.
5. Increased amount of spoiled work by new employes.

On the basis of these elements Mr. Alexander calculated that the cost of hiring a new man was between $35 and $40. Other investigators, continuing this study in other establishments, reached the figures of $60 and $100, and one writer went so far as to assert that " the wastage of the labor turnover is a hundredfold more costly than that of the strike." It was evident that such a process was not only costly to the worker, who, it has been estimated, loses from $20 to $30 between jobs, but it was even more costly to the employer. It was to remedy such an inexcusable situation that the new science of personnel management has developed.

The human factor in industry. — Production is carried on by the use of land, labor, and capital, which are combined by the enterpriser or the directing intelligence in suitable proportions. The land and the capital are inert and can be handled in such fashion as the enterpriser determines; but the human factor, labor, stands in a very different position. The work that is done is, after all, for the gratification of human wants; production is not an end in itself, but is a means to an end, which is human well-being. The laborer must therefore be taken into account when his labor is purchased, and his welfare must be considered. It would be illogical to produce goods for his consumption, and at the same time to treat him as a machine and overlook the character of his work and his fitness to perform it.

The effectiveness of an individual in his work depends in large measure upon the satisfaction which he finds in it, and this is determined by his qualification for it and interest in it. To increase production it is not sufficient merely to invent new machines and to devise new processes. It is also necessary to enlist the interest of the worker and to give him an incentive to put forth his best efforts. This incentive is usually assumed to be the wages paid; greater effort and enlarged production, it is held, can be obtained by raising the rate of wages. But a more careful analysis of economic motives and consideration of man's manifold nature, conducted by both psychologists and economists, have led to a greater emphasis upon the worker's satisfaction and interest in his work. In this is found a motive, comparable with the desire for a money wage in its effect upon output. A skilled worker enjoys effective workmanship, and dislikes futile effort.

The reality of this factor may be illustrated by the story of a carpenter, who, during the World War, deserted a steady job for one paying fancy wages at the naval proving grounds. A month later he was back at his old job, and when asked why he had left his new place replied, " Why, I couldn't stay there. I spent two weeks making a target and then they towed it out to sea and shot it to pieces."

Modern industry and the worker. — The illustration just given shows that the job must be adapted to the worker, but it is equally true that the worker must fit the job. It has frequently been assumed by employers that in employing workers they were hiring so many " hands " and that it was not necessary to make any inquiry into the fitness of the employes beyond their technical qualifications. And in the case of unskilled labor not even this was always required. Recently, however, there has grown up a new theory and practice of employment management, which attempts to apply the principles of the science of psychology to industry.

Previous chapters have shown that modern industry has created a society of specialists. Large-scale production and minute division of labor make very different demands upon the worker than did the handicrafts of the eighteenth century or even the small scale production of the nineteenth. The English guilds of the fourteenth century required that a boy serve an apprenticeship of seven years before he was admitted to the craft as an independent and qualified worker. But the system of apprenticeship broke down with the introduction of machinery and the increasing specialization of labor. To-day a certain amount of training is given by the schools, but most young men and women approach the work of life with little specialized training. A general education, which has carried them possibly through the eighth grade of the public schools, is the usual equipment of the majority of the workers in our factories and mills. Some manufacturing and business concerns and railways have provided training schools for their employes, which test and train the individual abilities of the men. Employment itself is an educative process and tends to make a specialist of each worker in the particular line of work into which he happens to have been thrown. But the particular industry for which he works and the particular job in that industry seem to be determined more frequently by chance than by a careful determination of the employe's qualifications. This point is well illustrated in the following quotation.[1]

Haphazard distribution of labor. — "The casual methods prevalent not only in employment work but in the handling of workers throughout industry in general is one of the anomalies of the age. For fifty years and more, the utmost attention has been paid to the development and refinement of the mechanical processes of manufacture. The division of labor has been carried to a point which would have been incredible a generation ago. *But the division of laborers is almost as haphazard now as it was then.* Now every large industry has its chemical and physical laboratory, in which it examines most minutely the quality of the materials which it receives and fabricates. But the effort during all this time devoted to the improvement of methods for handling *human* material has been ridiculously cheap and inadequate. As a single and a very practical instance of this easy-going policy, as applied to employment problems, the following quotation from an address to a convention of California railroad men is given:

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[1] H. C. Link, *Employment Psychology* (New York, 1914), p. 16.

'Would you, gentlemen, enter into a contract to buy materials from a concern, the excellence of whose product you had grave reason to doubt? Would you place orders to the extent of three and one-half million dollars a year, waive inspection of material, accept whatever was offered you, and make no effort to get your money's worth? You would not — not if you expected to hold your job. And yet, that is what you are doing with respect to the public education system of California. In 1916 the railroads of this state paid in operative taxes $7,151,583. Of this sum 51 per cent, or $3,647,300, was used for purposes of public education. *The boys and girls sent you from the public schools you take into your service, sometimes after a perfunctory mental examination, generally with none;* in other words, *you waive inspection,* and then complain of the character of the material after it has reached you and been paid for.' "

Scientific selection of workers. — If there are ten applicants for a job it will manifestly be to the advantage of the employer if he can select the one most fitted for the work. And on the other hand, if a boy graduating from school has a choice of ten positions at the same wage he will succeed best if he chooses the one for which he is best suited by his mental and physical qualities. Not only do the employer and the worker each gain as a result of this fitting of the man and his job, but if it is generally done society as a whole profits from a larger output of material goods and of human satisfaction.

Psychology has attempted to solve these problems and to introduce into the employment methods of to-day a more scientific procedure. Psychology applied to industrial employment is known as personnel work, and claims to have developed scientific methods in this field which will yield accurate results. Just as with land it is possible to analyze the chemical composition and physical properties of the soil, and thus to determine the kind of crops for which it is best suited; and just as in the case of materials for manufacture it is possible to determine exactly their qualities and suitability for a proposed use; so it is possible by mental and other tests for the psychologist to measure certain mental activities and thereby to determine the fitness of individuals for particular jobs. The determination of the fitness of the workers for their jobs is usually entrusted to the employment manager, while the selection of the line of employment which will best suit the capacities of the worker is the special task of the vocational counsellor.

Vocational guidance is sometimes given to graduates of our high schools, and formed an important part of the program of the Federal Board for Vocational Education in placing the ex-soldiers. In general, however, this phase of the double process of fitting together in a scientific manner the worker and his job is left to such casual advice or observation as he may be fortunate enough to obtain. Natural bent or inclination, the advice of parents or teachers, the openings which happen to be available at the time — any or all of these may determine his choice of an occupation. A certain selection takes place by trial and rejection, but at best there remain many misfits in our industrial system.

Mental tests. — In measuring the fitness of a candidate a direct trial at the job is often still the best method, but the scientific employment manager has some principles of selection which he applies before putting him to work. By some objective measurements or tests he endeavors to ascertain the candidate's abilities and achievements and aptitudes, and on the basis of these tests to reject the obviously unfit and to allocate the accepted candidates to the jobs to which they are apparently best suited. Among these objective measurements the mental tests devised by psychologists have attracted especial attention. A mental test is a device by which certain mental activities can be accurately measured. In schools and colleges these are perfectly familiar. Written examinations held under uniform conditions are used as requirements for entrance into high school or college or for promotion from one grade to another. Civil service examinations are a condition for admission to certain branches of government service and illustrate this type of objective measurement.

The use of psychological tests to determine industrial fitness is, however, a new experiment. It must still be regarded as in the early stages of development and application, but it gives promise of great usefulness. Where selection can be made by such tests rather than by direct trial in the shop or factory, a great saving in time and trouble and money can undoubtedly be effected.

Psychologists in the past have usually classified people from the side of mental deficiency, and careful studies have been made of the insane, the feeble-minded, and other groups of the mentally defective. Employment psychology, on the other hand, endeavors to classify the mentally efficient and by careful studies of their capacities and intelligence determine where they can be of greatest usefulness.

Special ability tests. — There are thousands of tests in existence to-day, and one of the chief tasks of employment psychology is to select the particular test which will be of value when applied to a particular job. In certain kinds of factory work, for instance, digital dexterity is desired, and the test which is used to sift out candidates for this kind of work must be carefully planned to determine this special aptitude. In general, special ability tests may be classified into two kinds, Oral and Performance.

" The Oral Test is the simpler of the two and is based upon the principle which is well established, that skill in a certain occupation parallels knowledge of that occupation. Consequently, the theory of the oral test is that by measuring the applicant's knowledge of the trade in which he claims expertness, the employment manager can secure reliable information as to the amount of skill in that trade which he possesses. The Performance Test is more direct. It is based upon the principle that expertness in any occupation is positively revealed by performance in that occupation and it attempts to concentrate into a few minutes or a few hours a selected variety of experience which ordinarily on the job might be extended over months or years. The Truck Driver's Test in the army camps was of this kind.

" The Truck Driver's Test was one of the first created by the Trade Test Division of the Committee on Classification of Personnel in the Army. The A.E.F. had had difficulty with certain units of truck drivers sent overseas by the General Staff. A request was made for a more careful selection of truck drivers. In several of the training camps these tests were set up and men who claimed ability as truck drivers and as chauffeurs were required to operate trucks under the conditions set forth in the test. In this test many fell by the wayside and were detailed to other work. Thereafter the men sent overseas as truck drivers proved much more efficient." [2]

Selecting girls as assemblers. — Another interesting application of psychological tests to the selection of workers during the war, which will serve as an illustration of this method, was in connection with the assembling of small gun parts.[3] Owing to the shortage of labor girls were being employed for the first time in this work and it was desired to devise some objective and simple tests to determine the fitness of candidates for this job. The work of assembling or putting together the parts in the finished gun consisted of taking small parts, placing them in the proper position, and then either hammering, screwing, pushing, or springing them together. It called for considerable manual dexterity and strength; the ability to pick up a part, size it up, and then decide just where it belonged and how it should be placed there. To determine whether the girls possessed these qualities they were given the following tests: (1) to test manual dexterity they were given a board from which pieces had been cut; these pieces were left on the board in their exact order and the girls were asked to replace them in their spaces as rapidly as possible, first with the right hand, then with the left, and finally with both hands. (2) To test the strength of the hands a grip-testing instrument or hand dynamometer was used. (3) Finally, to test the quick perception of odd shapes and sizes, another board was used from which odd shaped pieces were cut; these were arranged in a confused but predetermined order and the candidate was asked to put each piece in its proper place, making as few mistakes as possible.

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[2] Scott, W. D., and Clothier, R. C., *Personnel Management* (New York, 1923), p. 96–97.

Eighteen girls were tested for the work, of whom twelve were hired; ten of these had done well in the tests and two had done poorly but were nevertheless hired in order to give a negative check to the tests. At the end of a couple of months the foremen and the section boss were each asked to rank the girls and with one exception they agreed in their ratings. These rankings were then compared with the records of the girls in the tests and a remarkable agreement was found. The two girls who had made poor records in the tests had been dropped. The rank of the girls measured by their actual production corresponded most closely with their records for the perception of odd shapes and sizes, showing that this particular aptitude was of especial value in this work of assembling. But this peculiar ability could not possibly have been brought out by an oral interview or even by their experience in other lines.

Mental alertness tests. — Another form of test, which has been most frequently used and often misused, is the mental alertness test. This is designed to determine the presence of that particular quality of mind which we call mental alertness, or the ability to size up a situation quickly, to see its relation to other situations, and to reach sound judgment as to the best solution. Such qualities are needed in business rather than in industry and are especially necessary for those who may be entrusted with responsibility. They have been used for clerks, office boys, messenger boys, foremen, sales people, and similar groups, but have not proven themselves so valuable as the other tests already described.

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[3] This experiment is described in full by H. C. Link in his *Employment Psychology* (New York, 1919), pp. 53–61.

Another sort of test which is coming to be used more and more in the selection of workers is the physical examination. It is not enough that a candidate possess the mental qualifications for a job; he must also have the health and strength necessary to carry on the work.

But after all these tests have been applied there still remain certain intangible qualities which can be judged only by an intelligent interviewer. Among such qualities are personality, appearance and manner, initiative, judgment, perseverance, and tact. It is the business of the employment manager in a well-conducted personnel department to ascertain if possible whether a candidate possess these qualities, but this must be by personal contact and tactful questioning and not by the application of psychological tests.

The purpose of all these tests is of course to aid in the selection of suitable workers and to place them in those jobs where their powers can be most effectively utilized. But the work of a well-organized and administered employment department does not stop here. The men are watched after they have been assigned, and are directed, supervised, and developed. The working force should be welded into a stable, coöperative, and well-knit organization. The accomplishment of this ideal, however, involves other considerations which lie beyond the province of this chapter.

Increase of human happiness. — The purpose of the application of psychology to industry and of the development of scientific personnel management may be regarded as twofold: in the first place it aims to increase output and to reduce waste in industry; this is its economic side. In the second place, it attempts to increase human happiness; this is the human side. As a matter of fact the two cannot be separated. Where there is a maladjustment between an individual and his work there will result economic inefficiency, and the happiness or satisfaction of the individual will also be reduced. The two things go hand in hand. Even in machine industry the personal contribution of the machine tender counts for something, and the worker who is entrusted with the care of the machine must possess certain definite qualities if he is to succeed in that task. It must not be assumed that every one would be unhappy if assigned to that type of work; many individuals dislike responsibility and prefer a routine task. There are, however, certain conditions which, if they are present, will probably enhance the happiness or contentedness of the individual in his work.

The worker must of course have the requisite capacity to do the work; if he is not qualified he will not only do it badly, but will be dissatisfied while on the job. Moreover, the work should be of a character to absorb all his capacity, for if not there is a social waste of ability; for instance, a trained engineer might run a cutting lathe efficiently, but it would be wasteful, both from the standpoint of output and individual happiness, to assign him to such a task. Secondly, the worker must have an interest in his work; if he has not, he will probably be dissatisfied and will be planning to look elsewhere for work which does appeal to him. Under such circumstances he is mentally absent from his job a good share of the time and consequently does it poorly. The lack of interest may result from a maladjustment of the worker and his task, or from poor working conditions, lack of incentive, distance between management and workers, or large labor turnover. A third condition which must be met is opportunity for the worker to advance and to find self-expression in his work. Pride of workmanship is a motive which still exists in many lines of endeavor, even in some types of machine industry, while a definite promotional policy will act as a spur to the more ambitious and capable.

Modern industry has developed the technical side of production to a high degree. Raw materials have been exploited, machines have been invented, power has been developed and applied, and the processes of production have been efficiently organized. The human factor, however, has been given least study, and is only now beginning to receive the attention which it deserves. Tardily but steadily there is to-day developing a new science of human engineering which aims to conserve human resources as far as possible, to make them more effective in the work of production, and to increase human happiness.

SUGGESTIVE QUESTIONS

1. Do you know any boys or girls with talents or abilities so pronounced that their careers seem to be determined for them?

2. Inquire of some of your older acquaintances who are at work, why they are in their present positions.

3. Have you any idea of the kind of work you will do when you leave school? Why have you chosen this?

4. " Labor is a commodity and is bought and sold on the market like any other commodity." Do you agree with this?

5. Did you ever have a job? Was any test made of your fitness for it?

6. Describe some questions or tests which you know to have been used in hiring applicants for a job.

7. What sort of " inspection " would you propose for the human material which continuously flows from the public schools into industry?

8. Do you know of any establishment where the procedure is similar to that described in the text under the head of " hiring and firing? " Would you expect good results from such a method?

9. Find out what the labor turnover is in some establishment. What is the explanation?

10. Figure out the actual loss involved in an establishment with 60 employes, which has a labor turnover of 50 per cent, on the basis of the figures cited in the text.

11. Does it seem to you that a mental test, like an examination, is an adequate measure of mental ability? Why or why not?

12. Can you describe any test, like the truck driver's test in the army, which is used to determine fitness for a particular job?

13. Did you ever take part in a psychological test? What was its purpose? What did it prove?

14. It has been urged that selective tests should be applied to the candidates for entrance to the state universities, in order that the taxpayers' money may not be wasted upon persons who cannot profit by a university education. What do you think of this?

15. Ask some of your acquaintances who are at work whether they are happy in their work, and the reasons for their answers.

16. Do you think of any conditions which should exist, other than those mentioned in the text, if one is to be happy in his work?

BIBLIOGRAPHICAL NOTE

There is a wealth of literature on this subject, but much of it is of doubtful value as it is based on insufficient experience and is oversanguine as to the future. The application of psychology to industry, the sympathetic understanding and control of the human factor by employment management, is still new and much of the work is still in the experimental stage. With this warning the following books may be recommended.

An interesting study of motives in industry is O. Tead, *The Instincts in Industry* (New York, 1923). Methods of hiring the worker are described by M. W. Alexander, "Waste in Hiring and Discharging Employes" in *Scientific American Supplement* No. 2041, Feb. 13, 1915, pp. 102–103; C. R. Allen, *The Foreman and His Job* (New York, 1923); and R. W. Kelly, *Hiring the Worker* (New York, 1919). The application of psychology to industry and the development of personnel management are discussed fully in the following books: Meyer Bloomfield and J. H. Willits (Ed.) "Personnel and Employment Problems in Industrial Management," in *Annals of the American Academy of Social and Political Science,* Vol. LXV, No. 154, May, 1916; an excellent collection of papers by experienced men. Daniel Bloomfield (Ed.) *Employment Management* (New York, 1920); a good collection of a large number of short articles from all sources. H. L. Hollingsworth, *Vocational Psychology* (New York, 1916); a summary of experiments with psychological tests. W. F. Kemble, *Choosing Employes by Test* (New York, 1917); a description of a large number of tests, many only experimental. H. C. Link, *Employment Psychology* (New York, 1919); a stimulating account of experiments conducted during the war. Hugo Muensterberg, *Psychology and Industrial Efficiency* (Boston, 1913); written so early that it has only a theoretical interest. B. Muscio, *Lectures on Industrial Psychology* (New York, 1919), and E. J. Swift, *Psychology of Business* (New York, 1925), are of greater interest to the psychologist than to the economist. W. D. Scott and R. C. Clothier, *Personnel Management* (New York, 1923); both authors have done much experimental work in their field and President Scott especially has written voluminously; other books of his are *Increasing Human Efficiency* (New York, 1911) and *Influencing Men in Business* (New York, 1923).

PART III

NATURE AS A CONDITIONING FACTOR

CHAPTER XI

THE PHYSICAL FEATURES OF THE LAND

Factors of physical environment. — The physical environment may be separated into three groups of factors: (1) physical features and position; (2) climate; and (3) soil and mineral deposits. A complete understanding of even these factors involves an acquaintance with astronomy, physics, and meteorology, with geology, zoölogy, and botany, and with still other sciences, but our inquiry cannot extend beyond the purely geographical aspects. Stated in a narrower form, therefore, the question raised in the first paragraph of this book may be presented thus: How have geographical or environmental factors influenced the production of things useful to man and the development of industries for their manufacture, and to what extent have they modified man himself? The influence of each of the three sets of factors enumerated above will be considered separately.

The position and form of the continents. — If a globe or map representing the physical features of the earth be examined, it will be noticed that most of the large land masses are in the northern hemisphere, while in the southern hemisphere there is a great preponderance of water. The ratio of land to water is about 1 to 2 in the northern and 1 to 6 in the southern hemisphere. In this is to be found one explanation of the fact that practically all contributions to industrial progress have come from the northern half of the world.

But a further explanation of this fact may be found in the form of the continents. Another glance at the map will show that all of the continents are roughly triangular in shape, with the base of the triangle at the northern extremity. This condition is readily recognized in the case of North and South America, and of Africa. In the case of Eurasia a likeness to a triangle may be obtained by drawing two lines from the southern tip of India, one to the British Isles and the other to Kamchatka, though this triangle has a broader base and a more irregular shore line than the others. Australasia appears to be an exception to the general rule, but this is because much of that continent still lies beneath the surface of the water.

Effect on human development. — By reason of the triangular form of the continents it results that the greater part of those continents situated in the southern hemisphere lie near the equator, while the greater part of those situated in the northern hemisphere are in the temperate zone, which is better fitted for the development of a high type of civilization. The tropical conditions of the larger part of the land area of the southern group present obstacles to industrial progress, in part by reason of an unfavorable environment, whether it be the deserts of Sahara, the jungles of the Amazon, or an enervating climate which prevents the highest development of the human faculties.

On the other hand, in the " frosty continents " of the northern hemisphere, as Professor Shaler calls them, the conditions call forth the best that is in man. It is a curious fact that man reaches his highest development in regions which are subject to frost; here, if food and fuel are abundant, the human body attains its greatest size and vigor, and the mental powers are at their best. Fortunately for the human race the greater part of the land masses of the earth falls within this favorable zone.

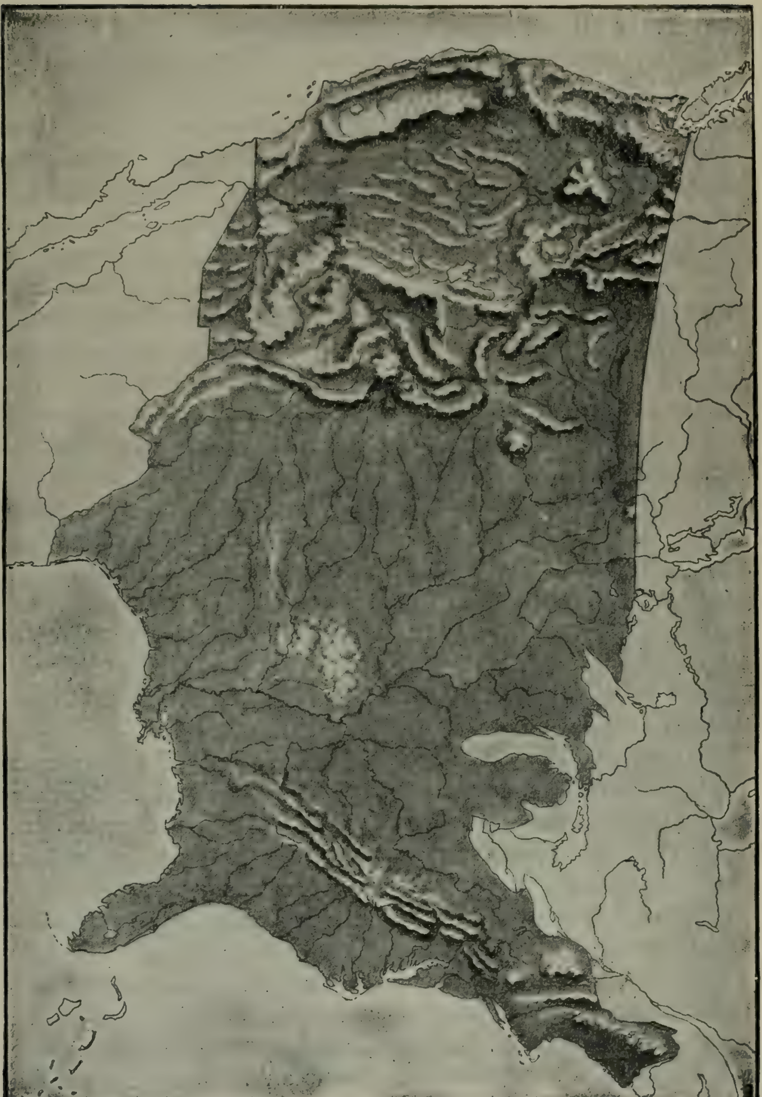
The effect of relief. — Another glance at a physical map of the world will show that the surface of the land is by no means smooth, but is broken by elevations and depressions. The relief of the land in the distribution of mountains, plains, plateaus, mountain passes, lakes, and swamps is important by reason of their effect upon climate and upon communication. The presence of mountains influences both rainfall and temperature. Thus the Rocky Mountains present an insurmountable obstacle to the moisture laden winds from the Pacific, causing them to deposit their moisture on the Pacific slope but preventing any of it from reaching the eastern side of the mountains. Fully a fourth of the area of the United States is thus condemned to utter sterility. The effect of mountains on temperature may be illustrated by the Riviera district of France and Italy, which is much warmer than the same latitude in America because it is protected from cold north winds by the Alps.

Mountains, swamps, and large bodies of water act as obstacles to communication, and thus may protect a race from invasion, or, on the other hand, may prevent it from communicating with other peoples from whom it might receive great advantages. Natural barriers may be either a benefit or a hindrance to development. Thus the Alps at one time separated and protected Italy from the other countries of Europe, but to-day prevent easy transportation. The Himalaya range which divides Thibet from India and the Andes range in South America have proved serious obstacles to transportation and communication.

The topography of a country has an effect also upon the political as well as upon the industrial development of the inhabitants. The peoples of mountain, plain, desert, and sea coast show marked differences along many lines. By reason of their isolation mountain tribes have little chance to exchange ideas and hence become clannish, but also very patriotic. With few industrial opportunities they remain backward and poor, but are bold, strong, and healthy. In striking contrast with the mountaineers, the people inhabiting the sea coast usually have a broad outlook, due to their contact with other countries and to their commercial pursuits. They are more progressive and possibly less nationalistic. Peoples of the deserts and tundras are least developed, due to their nomadic habits and constant wanderings in search of food.

The centers of world activity to-day are the lowlands and broad plains. The Atlantic slope, the Mississippi valley, and the great plains of northern Europe testify to this. On the plain occupations have a larger area in which to develop, land is more fertile and much more accessible than in the mountains, transportation is easier, and population is more thickly and evenly distributed. But the monotony of relief found in a plain tends to create a limited outlook and is thought by some to stifle creative genius.

Variety of relief. — For greatest progress, a varied topography is most desirable. Many different types of people are developed, and a greater variety of resources exists. Mountain regions furnish minerals, but not good lands for agriculture. Plains have abundant agricultural resources, but few minerals. A varied topography thus gives a greater variety of natural resources and makes for a more heterogeneous population. Knowledge is exchanged among all sections, which has a tendency to obliterate monotony and sameness of type. The industrial parts of Europe and the United States



Physical Map of the United States

all have a varied topography. Mountain and plain each gives its share in resources and influence upon thought. There is coöperation among all types of topography which results in making those countries the leaders of the world politically and economically.

Proximity to bodies of water. — The location of a country with respect to oceans and lakes is important because of their effects upon climate and transportation. Most rainfall is from water which was in the first place evaporated from the ocean. Lands in proximity to the ocean, therefore, generally have much greater rainfall than do those in the interior of a continent.

A good coast line is also of immense importance to a country from the standpoint of commerce. In this respect Europe is most fortunate, penetrated as it is everywhere by great arms of the sea, by gulfs and bays and estuaries which afford magnificent harborage and give access to the heart of the continent. Compare with this the monotonous contour of the African continent, and another reason for the industrial backwardness of the "dark continent" is disclosed. The importance of sea frontage is fully recognized to-day. Russia complains of being shut off from the open sea. Germany felt herself shut in and in the World War sought to push her boundaries to the north and west. When Poland was reconstituted as a state it was felt necessary to give her a seaport by the Treaty of Peace, while at the same time defeated Austria was deprived by way of punishment of her important seaports — Triest and Fiume.

Relation to other bodies of land. — The development of a country is influenced by its geographical position. Whether a country is insular or continental, whether near to or distant from the chief centers of activity, and whether communication with nearby lands is easy or difficult are factors to be considered. An important feature in the development of England and Japan is the fact that they are islands and difficult of invasion. Australia long remained unsettled simply because of its remoteness from the more progressive parts of the world. Spain, although geographically a part of the continent of Europe, is more like Africa than neighboring France; the explanation being that the Pyrenees Mountains are so difficult of access that the ideas and culture on the northern side have not been able to cross them, while from the nearby coast of northern Africa the Moorish influence has been strongly felt.

Location as a factor in progress. — During the ancient and middle ages, only those races progressed which sought and obtained a favorable location, a favorable location meaning one which was easily defended and which furnished an abundant food supply. Nearness to the ocean was an advantage but not a necessity. Conditions were good for the beginning of civilization in ancient Egypt, in the narrow fertile Nile valley cut off by the desert and the sea from contact with other races. A more favorable situation was the territory occupied by the early Grecian tribes. It was a fertile, well-watered land, with a mild climate and protected from invasion by a mountain wall on the north and by the sea on the other sides. The old Roman Empire owed its independent existence largely to the protection given by the sea and the Alps Mountains. Switzerland and Spain have also been protected against invasion many times by high mountains.

As soon as the agricultural stage was reached, in all of the older civilizations, a fertile soil was of first importance, while to-day a favorable climate seems to be the prime physical requisite for rapid progress. In any case there must be leisure before there can be progress. A surplus of the necessities of life is a requisite for leisure. Under ancient despotic rule, men could be forced to work, but a fertile soil gave the largest returns. Thus we find ancient civilizations in the river valleys of warm regions. These conditions were best for the production of food and the growth of population.

But when manufacturing began to be developed, the lead was taken by those countries which possessed the richest stores of raw materials and a type of people possessed of energy and inventiveness. These conditions were best met in the temperate regions, where a moderately abundant and cheap food supply was available, but where the climate was at times sufficiently cold to require sustained exertion on the part of the people. It has been found that the most rapid and the greatest progress has occurred within the frost belt; a moderate amount of cold seems essential to call forth man's highest capacities. Under normal conditions in these localities of favorable climate, the efforts of man are rewarded in sufficient abundance, that he can accumulate a surplus and thus obtain the leisure which is essential to all advancement.

The advantages of a large area. — The larger the area occupied by a people, other factors being favorable, the greater is the guarantee of their success and permanence. A broad geographic base means, usually, abundant command of the resources of life and development. Large area means long distances which render attack from the outside difficult and defense easy. Neither are large areas easily surrounded by invaders. Ordinarily large size also means a large population which furthers military defense and economic advancement.

Within a country of great size, such as the United States, resources are generally abundant and varied. Great variations in climate and soil permit of the production of a large variety of agricultural products. Total crop failures are not common. In case of local failures, other parts of the country may be drawn upon to make up the deficiency. Also a greater variety of minerals is found. There is also a greater possibility for a varied topography which, as has been shown, means much in the progress of a nation.

Again, a large area means numerous points of contact with outside peoples, and on this account there is less possibility of a premature crystallization of a country's civilization because of isolation. The British Empire has a cosmopolitan civilization because of its large area, scattered widely over the world and coming in contact with practically every nation in the world. There are usually differentiations of civilization along the frontier, and the longer this boundary line, the greater the possibility of contact with several different civilizations.

A large area also has political advantages. In the majority of cases, a large area brought under one political control has greater economic independence than a small area, and less likelihood of friction. The United States is probably more self-sufficing than any other civilized nation. Because of the abundance and variety of natural resources, insuring economic independence, and the extensive internal market, this country has been able to acquire a position as a world power in much less time than if its area had been small and its resources more limited.

Comparison of the continents. — Thus far we have considered only the physical features of the continents — their form, size, position, and general relief — but these are of fundamental importance, for they go far to determine the fitness of the various land areas for human occupation and development. It will be worth while therefore to compare the different continents on the basis of these factors.

In form, **North America** may be termed a normal continent, with its base in the arctic and its apex, a narrow isthmus, near the equator. From north to south it gradually narrows and the greater part of the land area lies within the temperate zone, thus giving an excellent basis for a good economic development. The shore line is comparatively regular, but in the numerous drowned river valleys good harbors are found. Rainfall is plentiful over a greater share of the continent, the region lacking it being the Great Basin, the western part of the Great Plains area, and the Mexican Plateau. Transportation routes are plentiful and good in the eastern two-thirds of the country and there are several passes through which the Rockies may be penetrated.

Europe has the best location of any continent. The largest part is in the temperate zone, while warm ocean winds give to northern Europe a temperature many degrees higher than for similar parts of other countries. It is also the most centrally located continent, being in the center of what is known as the land hemisphere. The north central part is a great plain beginning in England and extending eastward through Russia. This is the world's greatest plain in all respects, agriculturally, industrially, commercially, and politically. The mountains are low and, with the exception of the Pyrenees and Caucasus, easily crossed. This large plain and the relatively low mountains make transportation easy, and routes for transportation abundant. The numerous indentations of the sea benefit both climate and commerce. More area is subjected to the tempering influence of ocean winds and all parts are near to water transportation. There is no part of Europe that is more than 400 miles from ocean transportation and the average for the continent is about 209 miles.

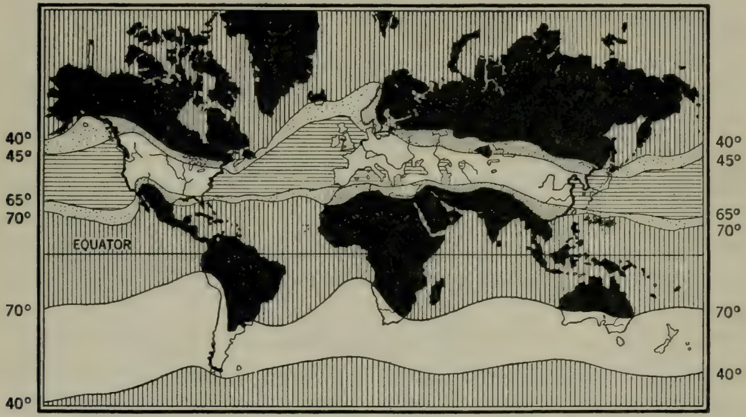
Asia is a continent of long distances, high elevations, dryness, great climatic extremes, and backward people. The people are unprogressive, because of the dry interior and their remoteness from the people of the industrially advanced nations. It is a land of mountains and plateaus. In northeast India the Himalaya Mountains, the highest in the world, centralize and then spread fanlike in both directions. Westward this mountain chain extends, broken at a few points, to the Pyrenees in Spain. The plateaus of the broad interior and of the western part are deserts pierced here and there by river valleys. Because of the distance of most parts from the ocean there are great climatic extremes. Drought, flood, and famine are common.

The greater part of the three southern continents represents both extremes of rainfall. Nearly all of northern **South America** and central **Africa** are uninhabitable because of high temperatures and heavy rainfall, resulting in an impenetrable mass of vegetation and an unhealthful, enervating climate. The apex of the triangle in these two continents lies in the most favorable regions. In the temperate areas they narrow down rapidly. Practically the whole of northern Africa and the western two-thirds of **Australia** are uninhabitable because of a scarcity of rainfall. Because of regularity of shore-lines, good harbors are scarce in South America and Africa. Australia has several indentations in her sea coast and a few good harbors. The construction of transportation routes is difficult because of the tropical nature of the country in northern South America and central Africa, and because there is a rapid ascent from the sea coast to high plateaus. In northern Africa and western and central Australia deserts retard the development of means of transport.

Importance of climate. — The second group of physical factors which determine industrial development are those usually summed up under the head of climate. This includes temperature, moisture, winds, and the amount of sunshine. Whatever affects either the temperature of the air over a place, or the amount of moisture present in the air, will affect its climate. Of all geographic factors climate is the most fundamental and important. It controls the distribution of plant and animal life upon which man depends, and through them the industry and commerce of nations. In the case of both heat and moisture, their amount, variations, and distribution throughout the year are important. To progress most a people must have the right degree of both temperature and rainfall, and the variations and distribution must be of such a nature that they can be utilized to the best advantage.

What determines temperature? — The factors which affect or modify the temperature of a region are: (1) latitude, (2) altitude, (3) position with regard to land and water areas, (4) position of mountain ranges, (5) exposure, (6) direction of the winds, (7) ocean currents, and (8) vegetation.

The nearer to the poles that one approaches, the cooler the temperature becomes. Near the equator, the heat waves from the sun strike the earth almost vertically, but as one leaves the equator they begin to strike the earth obliquely, and the farther one goes toward the poles the more oblique they become. In taking the oblique direction they strike the earth with less force and travel for a longer distance before striking it than where they fall upon the earth vertically. This longer oblique journey through the atmosphere causes their impact with the earth to be of less intensity than where they strike it vertically; consequently less heat is generated. The principle is the same as the striking of a nail with a hammer. A straight, direct blow on the head of the nail is more powerful and generates more heat than a glancing blow.



The Earth's Girdle of Civilization

The zone in which the mean average temperatures run between 45° and 65° F. is the home of the highest civilizations which the world has produced. The neighboring zones (stippled in the Northern Hemisphere) with mean annual temperatures between 40° and 45° and 65° and 70° are also areas of considerable industrial development. It should be noted how small a land area in the Southern Hemisphere is included in the zone whose mean temperatures lie between 40° and 70°.

The altitude of a place, or its height above sea level, also affects the temperature; for as the elevation increases the air becomes rarer and less able to retain the heat radiated into it from the sun-warmed earth. In going from the foot to the top of a mountain situated in the tropics one may pass through belts of temperature varying from tropical to subarctic. In general the temperature decreases 3° F. for every thousand feet of elevation.

The relation of a territory to other bodies of land or to large water area also affects the temperature. Land heats more rapidly than water in the more intense sunshine of summer, and on the other hand it cools more rapidly in the winter. A territory near the seacoast is therefore characterized by a more equable climate than a territory in the interior of a continent, where great and sudden changes in temperature, with long cold winters and hot summers, are common.

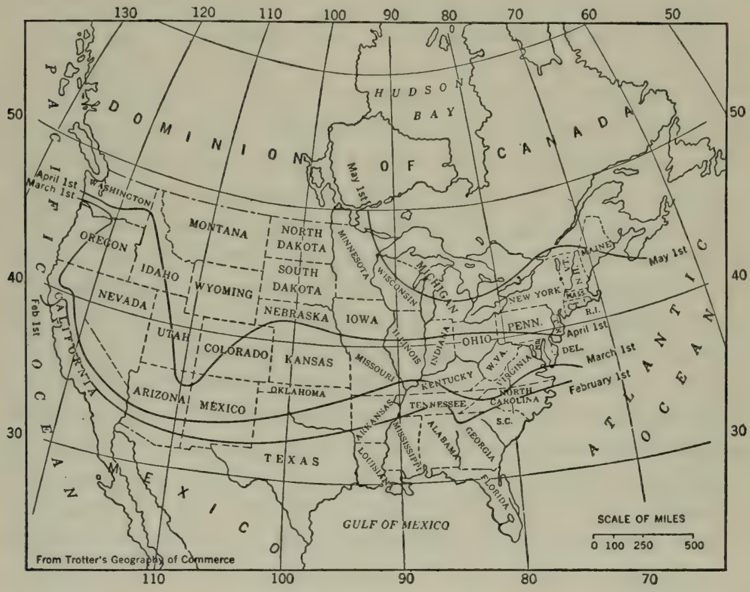
The presence of mountain ranges may influence the temperature through their altitude, and may also affect the temperature of surrounding regions by shielding it from cold or hot winds, or by causing a heavy rainfall on one of its slopes and scanty rainfall on the other.

Exposure or relief has a considerable influence on temperature. In mountainous regions, slopes with a southern exposure are much warmer than those facing in any other direction. Grapes are raised in the Rhine valley and in Switzerland on slopes facing to the south. These slopes are struck more directly by the sun's rays than are those with other exposures, and they are also protected from the cold north winds. Southern France, Italy, and India are protected and made warmer by the mountains to the north of them.

The direction of the winds also influences the temperature of a country over which they blow. Closely connected with this factor is the proximity of large bodies of water, and the presence or absence of ocean currents, which affect the temperature of the countries near whose shores they pass. Winds blowing off the sea are more uniform in temperature than those blowing over bodies of land. Consequently winds blowing from the ocean across the adjacent land will make it cooler in summer and warmer in winter — especially if the water be warmed by ocean currents — than it would be if the winds came from the land.

These factors are illustrated by the case of western Europe, near which flows a warm ocean current across which blow westerly winds that carry a genial warmth to the land. Labrador, on the other hand, in about the same latitude as England, is bleak and uninhabited because a cold arctic current passes nearby. New England is colder in winter than corresponding areas in Europe because of this cold current, and because, even though the warm Gulf Stream flows nearby, the prevailing winds blow over the land from the west rather than from the ocean, thus bringing additional cold air from the western plains. Because of the direction of the winds it is also hotter in summer.

Effects of temperature on plant life. — Solar heat is a necessary condition for life as it exists on the earth. Every known species of plant and animal life requires a certain amount in order to live and grow, and likewise the health and economic progress of man are determined in considerable degree by the temperature conditions under which he lives.



From Trotter's Geography of Commerce

The Coming of Spring

Northward movement of the isotherm of 43.8° F.

The degree of heat required to start the dormant activities of plant life is 42.8° F. When the average daily temperature in any district reaches this point, seeds begin to take root, trees and shrubs to bring forth their buds, and grass to grow. The northward movement of the isotherm (line of the same temperature) of 43.8° F., which is one degree higher, marks the beginning of Spring in the northern hemisphere.

Different plants and animals require different amounts of heat to complete their full cycle of growth; thus cotton requires a greater sum total of heat to effect its growth and ripening than does corn, and corn needs more than wheat. This relation of the plant to temperature is known as its "heat constant," which is the sum of the mean normal daily temperatures during the period required for its full development. The distribution of plants and animals throughout the earth in different climatic zones is controlled by this requirement.

Effects of temperature on man. — Man has more adaptability and can live in localities showing the greatest diversity of heat and cold, but his physical and mental powers are diminished by extremes in either direction. In a polar climate no plants can be grown for human use and all animal life is marine; there is therefore no economic basis for modern industry, although man can support life there. At the other extreme, the effect of excessive heat may prevent continued activity and render industry equally impossible, though for quite different reasons. As an illustration there may be cited the following description of the baneful effects of too great heat in the low moist climate of the Guinea Coast:[1]

"Nothing can be compared with the feeling of utter prostration that overcomes a European. Though he sits motionless in an armchair he is bathed in perspiration as after violent exertion. Nevertheless his fatigue is not like that felt after work, but rather a weakness in the limbs, and especially in the bones — an indescribable feeling of discomfort which precludes all movement, all bodily or mental work, but yet prevents sleep. . . . The head seems compressed in an iron band. Neither work nor reading is possible; either would require an effort of the will which we are incapable of making. Mental force is sapped even more than physical strength."

These are extremes, but other writers have shown[2] the relations between the seasons and human efficiency. Thus health and earning power are highest in New Jersey and Pennsylvania during the mild season from May to November, but both show a decided drop with the advent of the December cold and continue low during the winter. That there is a close connection between temperature and human efficiency seems indisputable. The highest development of the human race has been reached in a belt which is defined roughly in one direction by the limit of marketable timber and in the other by the line where snow regularly falls in winter.

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[1] A. Borius, *Climat de Senegal.* Quoted in W. D. Jones and D. S. Whittlesey, *An Introduction to Economic Geography* (Chicago, 1925). Vol. I, p. 109.

[2] E.g., E. Huntington and F. E. Williams, *Business Geography,* (New York, 1922), p. 66.

This belt falls within the annual isotherms of 32° F. and 68° F., and near the middle line of this belt, at the annual isotherm of 50° F., are situated almost all the great centers of modern civilization: New York, Chicago, London, Paris, Berlin, Vienna, Peking, and Tokio.

What determines rainfall? — The factors which determine the rainfall of a region are: (1) the presence of bodies of water, (2) the relief, and (3) the direction of the prevailing winds.

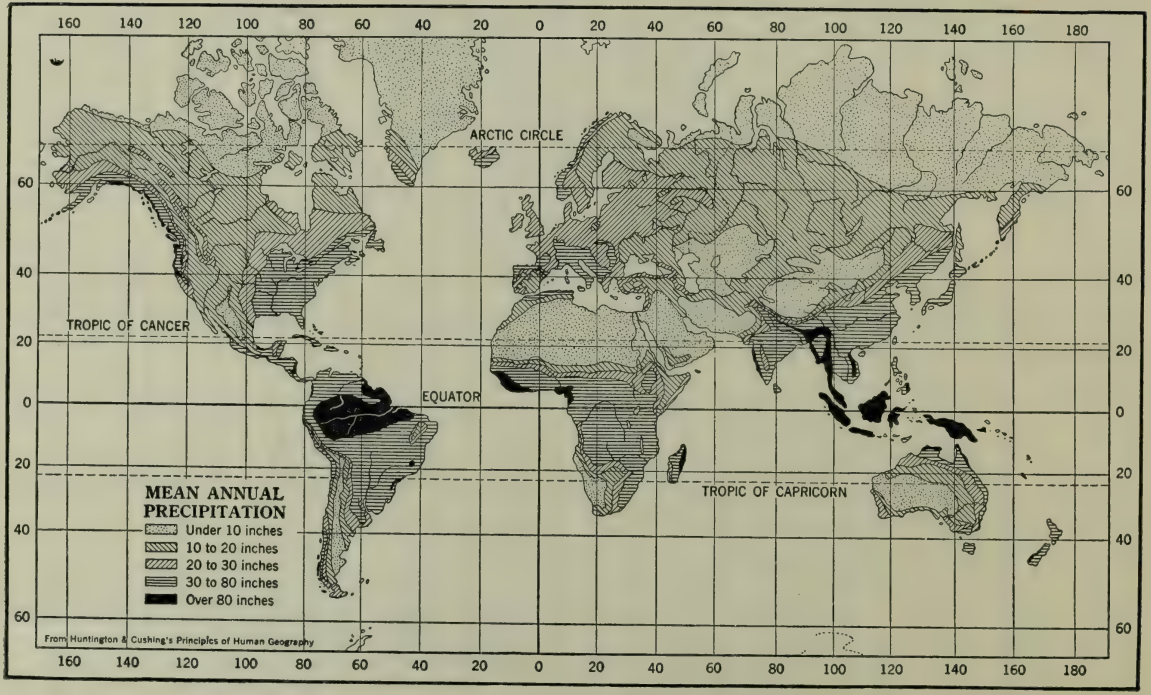
The presence of large bodies of water is necessary as a source of moisture. Most rainfall comes from sea water which has been evaporated and later cooled and condensed. Ordinarily sea coasts have a heavier rainfall than other sections of a country.

Relief is of consequence in the distribution of rainfall over a country. The mountain ranges of the Pacific coast are so high that most of the moisture becomes cooled before it reaches the top and therefore falls on their western slopes, leaving dry the Great Basin, Rocky Mountain, and Great Plain regions, which lie to the east of the mountains. The southern slope of the Himalayas is wet and the northern dry because of similar conditions.

The amount of rainfall in any region depends somewhat upon the direction of the prevailing winds, but more upon the nature of the areas over which these winds blow. The presence of the Sahara desert is due to the fact that the northeast trade winds are blowing from a cooler to a warmer region and thus are able to absorb more moisture instead of giving up any. In monsoon regions the winters are dry because the winds blow from the land; the summers wet because they blow from the ocean.

Importance of rainfall. — Plant and animal life are absolutely dependent upon the presence of moisture. By means of rain or irrigation many arid districts can be made productive, but without rain the most fertile land would speedily lapse into desert. Neither man nor animals could exist in a region which lacked water.

Just as a certain minimum amount of heat is necessary to awaken the dormant activities of plant life, so a certain amount of moisture is necessary to their continued growth. On the average, 30 to 40 inches of rain fall each year on the lands which contain the majority of the human family; 20 inches are considered to be the minimum needed for general agricultural purposes. The amount of rainfall, however, is not the only factor to be considered, for something depends on temperature and on the character of the



From Huntington & Cushing's Principles of Human Geography

Annual Rainfall

soil, and a good deal on the rate of evaporation and the time of the year when the rain falls. Thus evaporation takes place rapidly in a hot, dry climate, and consequently more rain would be needed there for a particular crop than in a cool moist climate. A sandy, porous soil loses its moisture more quickly than a good loam, and so requires more rain for crops. Much depends also upon whether the rain falls during the growing season, when it is needed most, or at other times. Thus corn requires about 14 inches of rain during the growing season, wheat 10 and rye 8, but if the climate were hot and dry, and the soil porous, much more might be needed.

On the other hand, too much rain is almost as great a disadvantage as too little. People who live in the humid regions are generally backward and unprogressive, and for this the climate must be held largely responsible. The vegetation is so abundant that it discourages their efforts at improvement, while the easily obtained food supply tempts them to sloth. As the rainy regions are usually also hot, the combination of heat and humidity proves very enervating.

What determines winds? — The unequal weight of the air on different parts of the earth is the cause of the wind. The greater heat of the sun near the equator expands the air in that belt and causes it to become lighter and therefore to rise as it does in a furnace. This warm light air tends to flow off to the north and to the south, and to create an area of low atmospheric pressure in the equatorial belt. But the outflowing air creates areas of high pressure in the subtropical belts of the northern and southern hemispheres. The effort of nature to correct these inequalities between the areas of low pressure and those of high pressure causes steady currents of air or wind to blow towards the equator and also towards the poles from the subtropical high pressure belts.

These winds would blow straight north or south if it were not for the rotation of the earth on its axis. This movement deflects the winds and causes them to blow in an easterly or westerly direction, according as they start out toward the equator or away from it.

These winds are so steady and so dependable that they have been called " trade " winds. Four principal belts of trade winds are of especial value to mariners; these are the north-east and south-east trade winds on either side of the belt of equatorial calm, and the two zones of westerly winds between latitude 40°

and 70°. It was these northeast trade winds which blew Columbus across the ocean to America, and which served navigators so long as they depended upon sailing vessels. A thorough knowledge of prevailing winds is even more important to-day to the aviator, who will go hundreds of miles out of his way to take advantage of a favorable air current.

Winds have also important effects upon temperature and rainfall, but these have been sufficiently described in preceding paragraphs.

The influence of climate. — The influence of climate upon man's development is shown in many ways, which may be briefly summarized. It affects the physical and mental powers of man; hot tropical climates prevent continuous or hard labor, extreme cold produces a torpid state, while temperate climates with a frosty winter call forth the highest exhibition of man's powers. The plant and animal life of a country is determined by its climate; some plants and animals are so sensitive that they will thrive only under very favorable conditions. Climate often determines the industries of a country; thus the cotton textile industry was first developed in the moist climate of Lancashire. And finally climate affects transportation and communication; where the winters are severe, rivers and canals are often blocked by ice, and land routes are rendered impassable by snow. The direction of the winds also helps to determine the routes of sailing vessels and of airplanes. These features will be better illustrated by a more detailed description of the climatic regions.

Climatic regions of the earth. — Climatically the earth may be divided into frigid, tropical, and temperate regions, each with its own characteristics of heat and moisture which leave their mark or influence upon animal and plant life and through them on human life.

In the frigid zone, plant life practically does not exist, the only forms being moss and a few small shrubs which do not require a large amount of sustenance from the soil and which can withstand the severe cold of those regions. Animals are scarce. Only those, such as the reindeer, which can browse on the sparse vegetation, or polar bears which live on fish, can exist. The water is the main source of food. In it are found walrus, seals, and also fish. Upon animal life then, human life in such regions must depend. The flesh of the fish and animals furnish food; their skins and furs provide clothing, shelter, and canoes; and their fat, heat and light.

In the cold regions too, one must spend most of his time securing food to supply daily needs and to last through the long Arctic night when but little can be done outside. Nature is so severe that all of man's energies are required to provide a mere existence. The time and means for intellectual improvement are lacking.

In the tropics one has to contend against the exuberance of nature. Temperature and rainfall are such that man needs to do little except collect the gifts of nature in order to live. Vegetation and food products are abundant. Heavy clothing and warm shelter are not necessary. But, as the cold prevents progress in the polar regions, so the great heat of the tropics hinders it here. The ease with which a living may be secured and the excessive heat combine to cause idleness on the part of the people. Everything is so plentiful that no thought is taken for the future. Sustained effort is impossible for any length of time. In addition there are all sorts of animals and disease-carrying insects in the tropics. Man can make but little headway against them and the abundant vegetation. Settlements in the tropics which embody the results of a higher civilization are usually on an elevated plateau where temperate surroundings are to be had.

Many people imagine life in the tropics to be easy, because food is so plentiful, but life there, because of disease due to high temperature and to insects, is the most difficult of any.

Desert regions are of two kinds, (1) those due to a lack of heat and (2) those due to a lack of rainfall. In the first class would be included the polar regions, and in the second the hot arid regions; in both, vegetation is lacking. The latter type is the one of interest here.

These deserts are dry, sand-blown wastes with very high temperatures, although at night the atmosphere cools quickly and the air may become chilly. At intervals an oasis is found where food and water may be secured. Around these oases, desert settlements are usually found. As in the polar regions, population is sparse. Herds can be kept, but the number of animals is limited by the scanty food supply. These herds furnish food, clothing, and shelter. The people move about often in search of pasture for their animals, which consumes much of their time. If pasturage becomes poor or exhausted, their animals may die. Then they resort to raiding, securing what they can from neighboring tribes. This type of people must be cautious and give some thought to the future, but they have very little time for progress. They can accumulate but little wealth, for they must spend most of their efforts in search of a livelihood.

The distinguishing characteristic of temperate regions is a period of growth followed by a period of rest or inactivity in the vegetable kingdom. This is due to changes in temperature, which, however, are not excessive in their extremes. During this season of growth man must work and store up a surplus to tide him over the period when the vegetable world lies dormant, and if he is at all energetic and ambitious he can generally store up something in addition to the actual requirements for existence. In this surplus lies the basis of all human progress. But there would be no progress were it not for the activity of man. For him the variations in temperature are of physical and mental benefit. The changes of temperature from season to season call forth effort on his part, but at no time are they so extreme as to dull his intellect or cause him to become indolent. Then, too, the variations from day to day, sometimes slight and sometimes of great range, stimulate him to activity.

Sustained and uninterrupted activity throughout the year are possible, and an incentive to industry is thereby given which is not to be found either in the tropics or the frigid regions. It is this condition, in combination with the surplus production, which gives time for leisure and for study, and paves the way for all progress. In the frigid regions, excessive cold hinders progress. In the tropics excessive heat and rainfall, and in the desert, excessive dryness have the same effect. But in the temperate regions there are the proper amounts and combinations of both temperature and rainfall to make those areas the centers of world importance economically and politically.

SUGGESTIVE QUESTIONS

1. Describe what you imagine the United States would be, climatically and agriculturally, if the Rocky Mountains were along the Canadian border instead of in their present position.

2. Show by the use of illustrations, how relief affects the production in a given region.

3. Can you determine why so many international conventions and congresses are held in Switzerland and Holland?

4. Explain why a surplus of production is necessary if man is to progress.

5. Explain the change of the seasons during the year.

6. Certain vegetables and cereals are grown in Alaska. How is this possible?

7. Describe, (a) the Mediterranean type of climate; (b) the monsoon type of climate.

8. Can plants and animals live out of their natural habitat? Give examples.

9. How best might we proceed to better the health and raise the general welfare of the natives of the tropics? (See Huntington and Williams, *Business Geography*.)

10. What winds and bodies of water are responsible for the rainfall of your own neighborhood?

11. About nine-tenths of New England remains untilled, and about one-tenth of Florida is untillable. What is the explanation of this difference? Can the untilled area of New England be otherwise utilized?

12. Enumerate certain countries, or areas within our own country, which are sparsely inhabited. Is this due to relief, or to climate?

13. What is the general character of the topography of the regions in which sheep raising is carried on? Cattle raising? Grain farming?

BIBLIOGRAPHICAL NOTE

Since Part III is a discussion of the geographical factors which affect man's existence a few general reference books that cover the entire field are listed first in order to save repeating them in the bibliography after each chapter in this part. The books which are given after each chapter are those that specialize upon some particular phase of the problem of that chapter.

One of the best authorities is E. C. Semple, *Influences of Geographic Environment* (New York, 1911). Covering much the same ground, but with more emphasis upon the historical phase, is A. B. Brigham, *Geographic Influences in American History* (Boston, 1903). Another excellent book, simply written, is N. S. Shaler, *Nature and Man in America* (New York, 1891). Other treatises which are elementary and outlined in detail are: A. J. and F. D. Herbertson, *Man and His Work* (London, 1917), and H. R. Mill, *Realm of Nature* (New York, 1892). Books which place much emphasis on the human element as affected by natural surroundings are Jean Brunhes, *Human Geography* (Paris, 1912) and E. Huntington and S. W. Cushing, *Principles of Human Geography* (New York, 1922). The former of these two books is the standard work on human geography, while the latter is written in a very readable manner and is better suited to the use of young students. Excellent works on regional geography are: H. R. Mill (Ed.) *The International Geography* (New York, 1905); John McFarlane, *Economic Geography* (London, no date); G. G. Chisholm, *Handbook of Commercial Geography* (9th ed. London, 1922); H. E. Gregory, A. G. Keller and A. H. Bishop, *Physical and Commercial Geography* (New York, 1910); L. E. Brooks, *The World* (London, 1922); and R. H. Whitbeck and V. C. Finch, *Economic Geography* (New York, 1924). The first three of these are most extensive and detailed, but the latter three can be used best by beginning students. Whitbeck and Finch have the best material and most systematic treatment of any.

Books which give a good explanation of the principles of physical geography are: R. D. Salisbury, H. H. Barrows, and W. S. Tower, *Modern Geography* (New York, 1913), and R. D. Salisbury, *Physiography, Briefer Course* (New York, 1908).

The standard works on climate are *Climate* (New York, 1908) and *The Climates of the United States* (New York, 1925), both by R. DeC. Ward. Another interesting and systematic treatment is W. G. Kendrew, *The Climates of the Continents* (Oxford, 1922). An excellent popular treatment is C. F. Brooks, *Why the Weather* (New York, 1924). An interesting and able book on the effects of climate with emphasis on the human factor is E. Huntington, *Civilization and Climate* (New Haven, 1915).

The books on climate also discuss the causes and effects of winds, but two special treatises on this subject may be mentioned. W. Ferrel, *A Popular Treatise on Winds* (New York, 1911), is an interesting and popularly written book. A brief but good discussion of the winds of the United States is C. P. Day, *The Winds of the United States and their Economic Uses* (U. S. Dept. of Agric. Year Book, 1911, Washington). Excellent short articles on winds are to be found in other volumes of this series.

CHAPTER XII

WATER AND WATERWAYS

The importance of water. — The presence of land is obviously essential to man's continued existence upon this globe, and does not need to be insisted upon. The services of large bodies of water and of rivers, in modifying the climate, furnishing means of transportation, providing power, and in other ways, are also well understood. But the services of water itself and the various uses to which it is put in our modern industrial society, are neither so obvious nor so generally recognized, and call for fuller presentation. Continents and oceans are physical features of the first order; mountains, plateaus and plains, coast lines and harbors, or modifications of land areas and bodies of water, are physical features of subordinate importance. Sufficient space has already been given to the minor features of relief, and it now remains to treat the major factors in greater detail. This chapter will therefore be devoted to water and the following one to land.

Uses of water. — The relation of water to human welfare is too comprehensive to be dismissed with a mere reference to rainfall. Its importance becomes evident if water in all its aspects, rather than merely in the form of moisture or rain, be considered. Water is present in such large amounts, over most of the globe, and is so generally distributed, that its importance is often overlooked. It is what the economists call a " free good," one which is provided without cost by nature, though its application to man's uses generally calls for an expenditure of labor and capital. A brief description of the chief uses of water[1] will show that it should be ranked high among a country's natural resources.

First among these uses is the satisfaction of human needs for drinking and household purposes. An adequate supply of good water is essential to the maintenance of human life, and its lack or insufficiency constitutes an effective bar to settlement.

Second in order of importance would seem to rank the uses of water for the production of food crops and other forms of vegetation and for watering animals. Man is dependent upon water for his supplies of food as well as for his own drink. And this is even more true of marine animals and plants than it is of land forms. It is in connection with these uses that water in the form of rain is most necessary, especially for growing crops of all sorts, and that irrigation and drainage assume importance. The amount of water cannot be increased in any given region, but the existing supply can be better conserved and distributed by man's efforts.

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[1] *Cf.* F. H. Newell, *Water Resources: Present and Future Uses* (New Haven, 1920), pp. 37, 179.

Closely connected with these two, especially in our cities, is the use of flowing water in the disposal of waste, both sewage and the waste from manufacturing industries. In many industrial processes and in nearly all sanitary appliances, water in large quantities is used. It is diverted from its normal channel, used for a short period, and then returned, generally carrying with it various waste substances which we wish to get rid of as easily and cheaply as possible. Often this use leads to serious stream pollution, which renders the water unavailable for the first two uses. Industrial and sanitary uses of water are essential to modern industry, but the waters returned to our streams after such use should first be deprived of their deleterious substances.

The mechanical employment of water in manufacturing is a fourth use. This may be for producing power directly, by a water wheel, or indirectly, by generating electricity, in making steam, and in other ways. As the subject of power is discussed more fully in a later chapter, this brief mention must suffice at this point.

Another use, of growing importance in the food industries, is that of ice, which is only water in another form, for refrigeration purposes. It would be impossible to distribute to the large populations of our industrial and commercial cities fresh fish, meat, eggs, dairy products, vegetables, and fruits without modern methods of refrigeration. Water is therefore indispensable, not only in growing food for human consumption, but also in preserving it.

Last in importance, from the standpoint of essential human needs, is the use of water for transportation. Accessibility to large bodies of navigable waters, as oceans, seas, and rivers, is necessary for purposes of foreign trade, while for domestic commerce inland lakes and rivers are equally important. Waterways were at one time the highways of the world's commerce, but have lost in relative importance through the development of roads and railways.

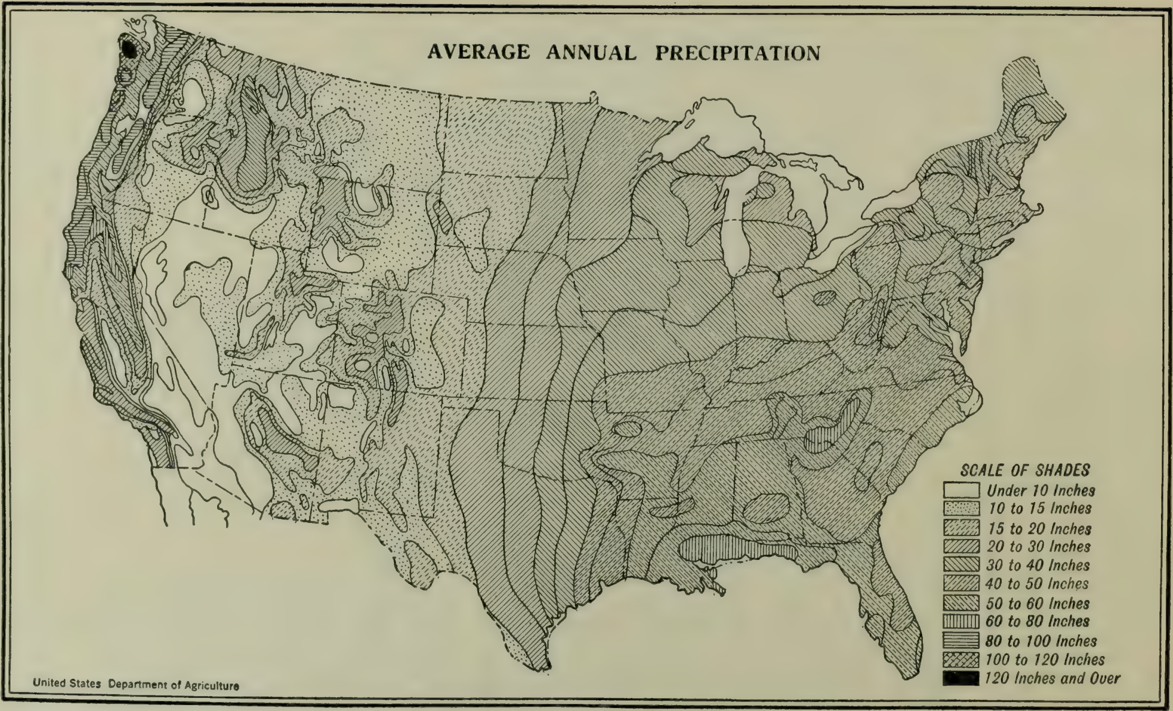
The waters of the United States. — In respect to all these uses of water the United States is well supplied. Except for a rather large semi-arid area, comprising the cordilleran plateau and the region immediately east of it, the land is adequately supplied with water for drinking and for the raising of crops. Even in the semi-arid districts sufficient water may be obtained for the former use by digging artesian wells, and for the latter by irrigation in limited areas. Since industrial development and urban life are both conditioned upon plentiful supplies of water, these cannot take place where water is restricted in quantity. This is one explanation — probably the most important one — why great regions of the Far West in the United States have never advanced much beyond a pastoral stage and why they can never become the seat of great industrial cities. The lack of water transportation may be made good by building railroads, but unless there is present water sufficient for the physical needs of man and animals and plants, for the disposal of waste, and for manufacturing purposes, man can neither live in the district nor develop industries there.

The accompanying map shows the average annual precipitation in the United States. Details as to the land area within each of the precipitation zones are given in the following table:

AVERAGE ANNUAL PRECIPITATION IN THE UNITED STATES

Amount of precipitation	*Land area, acres*	*Per cent of total land area of U. S.*
Under 10 inches	153,634,432	8.1
10 to 20 inches	588,775,719	30.9
20 to 30 inches	314,258,301	16.5
30 to 40 inches	320,089,545	16.8
40 to 50 inches	324,846,189	17.1
50 to 60 inches	160,366,829	8.4
60 to 80 inches	28,898,105	1.5
80 to 100 inches	9,430,528	0.5
Over 100 inches	2,915,712	0.2

The functions of oceans. — Chief among the functions of oceans are their services as (1) sources of moisture, (2) modifiers of temperature, (3) builders or destroyers of land, (4) sources of food and of raw materials, and (5) avenues of transportation.



Precipitation includes rain, melted snow, sleet, and hail. The map is reduced and generalized from the one prepared by the Weather Bureau and published in the Precipitation and Humidity section of the Atlas of American Agriculture. The map suggests why the United States should be divided agriculturally into an eastern and a western half.

Almost three quarters of the area of the globe is covered by the oceans, and they thus constitute the chief source of the moisture which is drawn up by evaporation into the atmosphere and falls upon the earth in the form of rain. The oceans also modify temperature; but the influence of the proximity of the ocean depends upon the direction of the prevailing winds. Thus the climate of New England is colder than that of Great Britain, although the Gulf Stream washes the shores of both, because of the cold Labrador current and because the prevailing westerly winds blow away from the New England coast toward the ocean, while in the case of Great Britain they blow over the warm ocean current before they reach the land.

The waves of the ocean are constantly wearing away the land on the coast and washing down material which has already been loosened by chemical disintegration and weathering. Examples of this may be found on the coasts of Cornwall or of New Jersey. In some places new land is formed by the washing in of earth material. On the whole, however, the destruction exceeds the construction.

The oceans are storehouses of resources useful to man. Fish form an important article of diet, which has become more general as improved methods of preservation have been devised. Many other marine products are utilized for man's needs, such as salt, sponges, corals, pearls, etc., or form the raw material for important industries. Thus iodine is manufactured from kelp, buttons from shells, whalebone and sperm oil from whales, fertilizer from seaweed and fish, and many other products from other forms of marine life.

The function of oceans second in importance — their influence on climate ranking first — is their use as great highways of commerce; access to them is regarded as essential by the leading commercial nations. The ocean was an impassable barrier to primitive peoples, but to-day it has become the most convenient transportation route from one continent to another, and even between different sections of the coast on the same continent. Without this cheap and far-reaching route it would be impossible to move the bulky agricultural and mineral products from one part of the world to another, and international trade would be reduced to a fraction of its present dimensions.

Position of the United States. — The situation of the United

States with respect to ocean waters is fortunate, for its shores are washed by both the Atlantic and the Pacific. The people of this country can therefore avail themselves of convenient avenues of ocean transportation to Europe and Asia, to the other American continents, and to Africa and Australia. The oceans have proved also to be stores of food, and furnish the basis for flourishing fishing industries; cod, mackerel, and herring are the most important food fish caught in the Atlantic, and salmon are even more important in the Pacific fisheries. Raw materials, such as kelp for making iodine and potash, oyster and abelone shells for the manufacture of ornaments, coral for similar purposes, sponges, and other valuable articles, are obtained from both oceans.

The influence of the oceans in modifying the temperature and contributing to the moisture and rainfall is not so marked in the case of North America as in some other continents, on account of the relief of the country. The prevailing winds blow from west to east and consequently blow from the land to the ocean on the Atlantic Coast. On the Pacific Coast the moisture and warmth of the ocean are carried to the land from the ocean, but they cannot penetrate far inland because of the ranges of high mountains running parallel to the coast, which constitute an effective barrier. In neither case therefore are the beneficial effects of the proximity of the oceans in these respects so widely distributed as might be expected.

The functions of inland bodies of water. — Rivers and lakes serve as (1) means of drainage, (2) reservoirs, (3) sources of moisture for rainfall, (4) equalizers of temperature, (5) regulators of streams, (6) sources of food and minerals, (7) means of irrigation, (8) means of waterpower, and most important of all, (9) means of transportation.

All inland bodies of water take care of surplus rainfall, otherwise much of the land surface would be swampy and unfit for use. Lakes are natural reservoirs and rivers can be made to serve as reservoirs by building dams. In this manner water is secured both for irrigation and for power. Lakes serve to a small extent as sources of rainfall, and to a greater extent as equalizers of temperature, but the importance of rivers in both these respects is negligible. Thus Michigan and northern New York have important fruit growing areas because the cold water surface of the lakes makes a cool temperature, which delays budding and blossoming until after the danger of frost is past. Most bodies of water contain fish, and a few, like Great Salt Lake and the Dead Sea, contain minerals, especially salt, but the amount of both food and minerals taken from inland bodies of water is not large. It is as a means of transportation and source of water-power that these bodies of water are of greatest value; only the former of these two subjects will be dealt with in this chapter.

Importance of waterways. — The importance of waterways is shown by the fact that practically every large city of the world and most of the medium-sized ones are located upon some sort of waterway, either ocean, lake, or river. This is due in part to the fact that most modern cities had their origin at a time when water transportation was the only cheap mode of travel, the use of railroads not being known then. Indianapolis is an example of a rare type of city, which owes its existence almost entirely to its advantages in railroad transportation.

Although access to the ocean is essential it will be noticed that most of the great commercial centers are situated at or near the mouth of a river, or at the end of navigation. River valleys were the foci of early civilizations, and in backward countries the majority of the population still inhabits the river valleys. The Nile and the Tigris-Euphrates valleys were the cradles of early civilizations. In ancient Greece and Italy the river valleys harbored the people. In present-day India and China, most of the population is found in or near the valleys of the chief rivers traversing those countries.

River valleys were originally important because they furnished food and provided a cheap and ready means of transportation, and because they were the most fertile and productive parts of a country. To-day, in addition to the above advantages, river valleys furnish the best routes for artificial transportation lines to follow.

Lakes of the United States and Canada. — With the exception of Lake Michigan, which is wholly within the United States, the Great Lakes are open to the use of the United States and Canada on equal terms. This chain of lakes, with the St. Lawrence River in Canada and the New York Barge Canal and Hudson River in the United States, forms one of the greatest inland water routes in the world. The shore line of these lakes in the United States is 2,700 miles from headland to headland and about 4,300 with indentations; their area is about one-half that of the Mediterranean Sea. Their handicaps are their being frozen about four months out of the year, the lack of good harbors, and the occurrence of heavy snow storms and dense fogs.

The moisture from these lakes causes a dense growth of forest some distance back from the shore and supplies some rain to the center of the continent, but the winds do not blow inland regularly and in winter the warm light air of the lakes with its burden of rain can not penetrate the heavy winter air over the land.

These lakes carry an enormous amount of traffic, of which over half is iron ore, and the remainder chiefly coal, grain, and lumber. There are established lines of steamers between most of the cities on the lakes, some of the important ports being Duluth, Superior, Port Arthur, Chicago, Gary, Milwaukee, Port Huron, Detroit, Cleveland, and Erie.

Requisites of a navigable river. — To be important as carriers of commerce rivers must in the first place have sufficient width, depth, and length, to permit of their extensive use by fair sized vessels. The current should not be too swift nor the fall too great; otherwise there are likely to be falls and rapids which obstruct navigation. Neither should the current be changeable and the channel subject to filling by sand bars. The channel should be of nearly uniform depth throughout its course and during the year in order to be used to the greatest advantage, and it should also be ice-free. Moreover, a waterway should possess a good hinterland, i.e., a bordering region rich in products to be carried to market. Finally, a river must flow in the right direction if it is to be utilized extensively. The reason for the importance of the Rhine as a carrier is because it flows through the densely populated industrial districts of Germany and has its mouth in the region which is the center of the world's foreign trade. There are a large volume of products to be carried and a large market waiting to absorb them.

The rivers of the world which probably fulfill these requirements best are the St. Lawrence, the Hudson, the Rhine, and the Elbe. Other important ones, which are not quite so well situated, are the Amazon, Yangtze, Volga, Danube, Seine and Thames.

The St. Lawrence River. — With increasing industrial development of the interior of the United States and Canada, the St. Lawrence River will probably become one of the most important rivers in the world for carrying traffic. In combination with the Great Lakes it furnishes a route of about 1,700 miles, tapping the agricultural interior of the continent. Moreover, its mouth faces Europe, which is our chief market for agricultural products.

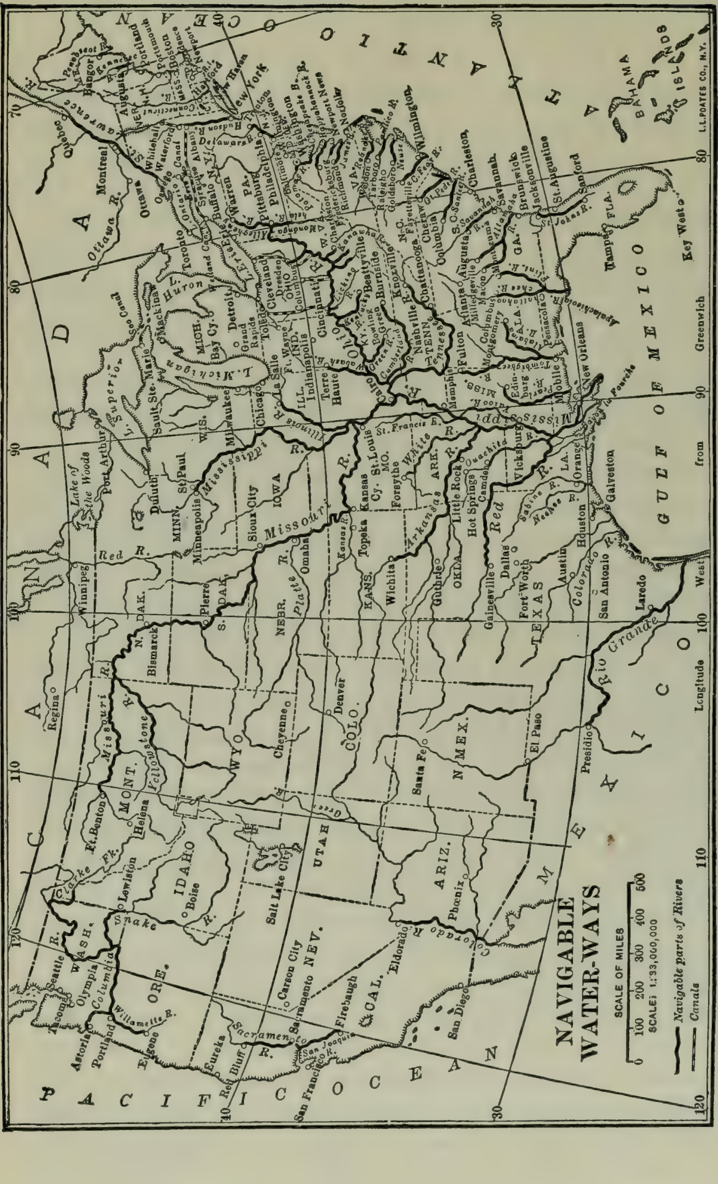
The river has its source in the Great Lakes and is thus assured of an even flow of water throughout the year. In addition its course is straight. The mouth of the river is a large estuary unexcelled in the world for length, breadth, and depth, extending 250 miles from the Atlantic Ocean to Quebec. Ocean steamers can go to Montreal. The handicaps are ice, which closes the river for three months in the year, and the Lachine rapids. A canal has been built around the rapids, so that moderate sized boats can now proceed to the Lakes.

In addition to the St. Lawrence, Canada has eight other rivers, each with a navigable length of over 1,000 miles, and about 3,700 miles in canals. The Mackenzie, 2,400 miles in length, is one of the largest. The Rideau canal and river connects Kingston with Lake Ontario and the Ottawa river. The possibilities of using Hudson Bay when free from ice are being investigated and it is claimed that this route may be of much importance in shipping out the wheat of north central Canada. In general, the Canadian waterways lack development, but the people of Canada are giving much attention and thought to waterway improvement. Development thus far has been carefully planned and worked out.

Rivers of the United States. — The rivers of the United States may be divided into three groups, (1) the rivers of the Atlantic coast, (2) the Mississippi system, and (3) the rivers of the Pacific coast. In total, the United States has about 26,000 miles of navigable waterways, 2,500 miles being canals. In addition there are 2,500 miles of bays and sounds that could be connected by canals and utilized, and 25,000 miles of rivers, not now navigable, some of which could be improved and used if the need arose.

The Atlantic coast rivers. — Along the Atlantic from Maine to Florida there are about 150 rivers navigable for varying distances.

These rivers are all navigable for small boats to the fall line. In New England the average distance is less than 50 miles, while south of the Hudson it is greater. Some of the important New England rivers are the Penobscot, the Kennebec, the Androscoggin, the Saco, and the Connecticut, which is the largest New Eng-



The heavy lines show the navigable water-ways of the United States, in which the water is three feet deep or over. The length of these is some 18,000 miles.

land river, being 345 miles in length. All of these rivers originate in lakes and have a uniform flow of water. The Kennebec is one of the best power streams in the United States, the average fall for the whole length of 150 miles being 8½ feet per mile. The Merrimac is another river famous for its power. Haverhill, Lawrence, Lowell, Nashua, and Manchester, all important manufacturing towns, are situated on the Merrimac.

The most important navigable river of the Atlantic coast is the Hudson, which is one of the most used commercially in the United States. It is 300 miles long but is navigable only as far as Albany, about one-half of its length. Below Albany it is a drowned river valley, and is deep. Above Albany it gets shallower and has a rapid current. At Albany it is joined by the New York Barge Canal. Tides extend to Troy and over the navigable portion the fall is only five feet for the whole distance. This river is straight, has a good hinterland, and flows in a good direction.

South of the Hudson there are several navigable rivers. There is plenty of rainfall and the mouths of the rivers are estuaries, so that they are wide and deep. In addition there are tides in many of them. The Delaware is navigable to Trenton, and outranks the Clyde River in shipbuilding. The Potomac is open to ocean ships to the fall line and the James is navigable to Richmond, but both of these rivers are subject to great fluctuations. Farther south the Chowan, Roanoke, Tar, Neuse, and Cape Fear are navigable for considerable distances. The Pedee is navigable nearly across South Carolina. The Wateree is navigable to Camden. The Congaree is navigable to Columbia. Ships go up the Savannah to Augusta, 250 miles, to Milledgeville on the Oconee, and to Macon on the Ocmulgee. In all of these rivers south of the James a great deal of power is developed.

The Mississippi system. — The Mississippi is the only important navigable river on the Gulf coast. The Rio Grande, Brazos, Red, Alabama, and Warrior are navigable for short distances. The Mississippi and its tributaries, of which the most important are the Missouri, Ohio, Red, and Arkansas, have about 10,000 miles of navigable waters. The Mississippi is about 3,000 miles in length and carries one-third of all the river water of the country. It pours into the Gulf of Mexico every minute a volume of water which would cover 20 acres of land 41 feet in depth. Ocean steamers can reach New Orleans, where the width is a little over a half mile and the depth about 60 feet, but the various mouths of the river are shallow. Boats of about 30 foot draught can now go out through South Pass, the outlet most used. The river is navigable to the Falls of St. Anthony for small sized boats, but is not used much above St. Louis. It is subject to great fluctuations in depth and the channel shifts often. Great amounts of money would be required to maintain the river in navigable condition at all times.

The Ohio is the most important commercial tributary of the Mississippi. It is about 1,000 miles in length and is navigable, for small boats, to Pittsburgh. Regular service is established between Cincinnati and Memphis. There is a canal around the rapids at Louisville. The Ohio is a better waterway than the Mississippi because it has a steadier flow and does not shift its channel so much.

The Missouri River is similar to the Mississippi in all of its characteristics. It is about 3,000 miles in length and is navigable for flat bottom boats to its junction with the Yellowstone River. It is wide, shallow, and muddy, with great variations in water and a shifting channel. It is scarcely used at all in a commercial way.

Pacific coast rivers. — The rivers of the Pacific coast have a combined navigable length of about 2,000 miles. The Columbia is the most important of the group. It is 1,400 miles in length and with its tributaries, chief of which are the Willamette and the Snake, it drains all of the northwestern United States. Improvements will open up about 2,000 miles of water to navigation on this system. The mouth of the Columbia is an estuary about 35 miles long and from 2 to 7 miles wide. There are 35 feet of water to Vancouver and ocean-going vessels can reach Portland, 110 miles inland.

Other streams with short stretches of navigable water are the Colorado, the San Joaquin, and the Sacramento, the latter two being nearly parallel with the coast. In a discussion of western waterways the Golden Gate, Puget Sound, and the Strait of Juan de Fuca should not be forgotten.

The Yukon River. — The Yukon River with its tributaries ranks fifth among the rivers of the world in miles of navigable water. The Yukon itself is about 2,050 miles in length and is navigable for about 1,850 miles. Its head waters are in British Columbia and there are canyons through which it runs rapidly and and flats where the current is sluggish. As it frequently shifts its current, navigation is made difficult. Its mouth is a delta about 80 miles wide. On account of ice it is open only about 3½ months out of each year, but is an important means of transportation for the interior of Alaska.

Why canals are built. — Canals are artificial routes, but since they are a means of water transportation, they will be treated in connection with rivers and lakes. Canals are built for strategic and industrial purposes. Such canals as the Panama, the Suez, and the Kiel serve both purposes, while others are important chiefly in an industrial way. The Panama and the Suez canals, in addition to being of commercial advantage by shortening routes, are important in the scheme of defense of the United States and of the British Empire. Since it is now possible to go from one coast of the United States to the other in shorter time, the nation can be defended by a smaller navy and warships can hasten to areas of trouble in much less time than formerly. The same is true of the Kiel and the Suez canals. The Kiel Canal, which is now internationalized, was part of the general scheme of German defense before and during the World War.

Canals for industrial purposes are built to shorten routes, to provide less dangerous routes, to go around rapids and falls, and to make new routes. Many canals combine two or more of these advantages. The Panama and Suez canals were built to shorten routes. The Cape Cod Canal in Massachusetts shortens a route and eliminates the danger of storms. The Welland and Soo canals were built to get around falls in rivers. The New York Barge Canal and all of the vast network of canals in the interior of Europe are new routes which connect other bodies of water, but which were not built primarily for any of the other three purposes. They extend and supplement the existing means of water transportation. A great many rivers must be improved and canalized before they can be used extensively.

Canals of the United States. — The important canals of the United States are the Soo, Welland, New York Barge, and the Panama. The Welland is in Canada, but it is so closely associated with the commerce of the United States that it will be discussed with other canals of the United States.

The Sault Sainte Marie or Soo Canal is less than a mile in length and consists entirely of locks. The Poe lock, which is the largest canal lock in the world, is 800 feet in length, 100 feet in width and will admit vessels with a 20-foot draught. More than six times as many vessels pass annually through this canal as through the Suez, and it has the greatest volume of traffic of any canal in the world. This is due largely to the bulky nature of the products passing through it, the chief of which is iron ore. There is also a similar but smaller canal on the Canadian side. Both were dug to enable ships to get around the rapids of the St. Mary's river in going between Lake Superior and Lake Huron.

The Welland Canal between Lake Erie and Lake Ontario is the means of carrying Canada's lake commerce around Niagara Falls. It is 14 feet deep, but improvements in progress will increase the depth to 25 feet.

The New York Barge Canal connects Lake Erie at Buffalo with the Hudson River at Albany, a distance of 363 miles. Originally it was 70 feet wide and 7 feet in depth, but improvements have increased these to 200 feet and 12 feet respectively.

The Panama Canal, the greatest in the world, was built and is owned by the United States. It is 50 miles in length, has a minimum width of 500 feet at sea level and 300 feet in the higher portions and will accommodate vessels of not over a 40-foot draught. It shortens the distance between New York and San Francisco by 9,500 miles.

Other canals are the Chicago Ship and Sanitary Canal between Lake Michigan and Lockport; the Ohio Canal, connecting Lake Erie with the Ohio River at Portsmouth; the Miami Canal connecting Lake Erie with the Ohio River at Cincinnati; the Wabash Canal from Lake Erie near Toledo to the Wabash River; the Chesapeake and Ohio Canal, originally designed to connect Chesapeake Bay with the Ohio but which did not get beyond the mountains; the Chesapeake and Delaware Canal between Chesapeake and Delaware bays; and the Cape Cod Canal across Cape Cod in Massachusetts. There are also several small canals in the vicinity of New Orleans, the Houston Ship Canal from Houston to the Gulf, and several small canals connecting the Finger lakes and rivers of New York state with the New York Barge Canal.

The Chicago Ship and Sanitary Canal was built to carry away the sewage of Chicago and in its construction the course of the

Chicago River was reversed. It has a minimum depth of 22 feet and is 160 feet in width at the bottom. All bridges are movable and it may become an important factor in the proposed Lakes-to-Gulf waterway.

Of the remaining canals the Chesapeake and Delaware and Cape Cod canals are the most important ones because they greatly shorten the distance between two bodies of water which they connect. Traffic on the remaining canals is not large, and consists principally of iron ore, coal, and building stone.

Harbors. — Harbors are terminal points where inland commerce meets that of the ocean, or where there is a change in the methods of transportation. The terms harbor and port should be distinguished. A harbor is a protected section of the coast, while a port includes both the harbor and all of the facilities for handling goods. A good harbor is the work of nature, a good port partly the work of man. Channels may be dredged and artificial harbors constructed in some cases, but a good natural harbor is an asset which gives its possessors a commercial advantage over their neighbors not to be offset by the expenditure of large sums of money. Good harbors depend upon the physiography of a coast line and the force and direction of waves and currents.

Characteristics of a good harbor. — A good harbor must furnish (1) sufficient depth of water leading from anchorage to the open sea to accommodate the largest ships; (2) protection from storms and waves so that ships may safely load and unload: (3) anchorage room spacious enough to accommodate many ships; (4) abundant space for the construction of all facilities required in handling traffic; (5) a straight channel without bad currents; (6) freedom from ice at all times; (7) absence of shifting sands and the inflow of sediment which would tend to choke it up and lessen its depth; and (8) freedom from rocks and reefs which would endanger the passage of ships. A harbor might possess all of the above advantages, but unless it possessed (9) a good hinterland and (10) easy access to this hinterland it would lie practically useless. The hinterland should be one which produces a large volume of products for sale and one which will at the same time consume large amounts of goods from other regions.

Harbors of the United States. — Along the Atlantic Coast some of the best natural harbors are New York, Baltimore, and Norfolk.

On the Gulf Coast are New Orleans and Galveston, and on the Pacific, San Francisco, Portland, and Seattle. There are of course many other important harbors on all the waters which border this country, but these are the outstanding ones which meet best the conditions laid down in the preceding paragraph.

Baltimore, Maryland, Harbor and Sky Line from the Water

SUGGESTIVE QUESTIONS

1. Find out how San Francisco and New York City obtain their supplies of water. What are some of the problems involved?

2. Discuss the problems of sewage disposal in Chicago (Foreign Affairs, June, 1926); New York; Berlin; Paris.

3. Make a list of the large cities of the world that are not located upon some sort of a waterway.

4. Explain why many of the large seaports of the world are situated inland on a bay or large river rather than directly on the ocean.

5. Point out the extent to which the Rhine River fulfills all the requirements of a good commercial waterway.

6. What is the nature of the traffic over the Great Lakes? Why this particular traffic?

7. Locate the important canals of the United States on an outline map.

8. How do you explain the slight development and use of canals in the United States?

9. List the chief seaports of the United States in the order of their importance. What are the chief products passing through each port? (See Statistical Abstract of the U. S.)

10. What has been the effect of the building of the Panama Canal on the development of seaports and railroads in the United States?

11. Make a list of the ports of the world that have the most ideal hinterland.

12. From what direction do the prevailing winds blow in your home town when it rains? Which winds bring hot weather? Why?

13. Should the St. Lawrence waterway project, to permit the passage of ocean-going vessels to the Great Lakes, be approved?

14. Would you conclude that the United States is favorably situated with regard to natural waters?

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CHAPTER XIII

THE LAND

Soil and mineral deposits. — In the previous chapters the physical characteristics of the land and the climate were considered in their effects upon man and industry. This chapter will discuss the importance of the third group of physical factors making up the environment, namely the soil and mineral deposits. Grouped together these constitute a valuable part of a country's natural resources.

After climate, soil is the most important element in the physical environment. The nature, variety, and distribution of soils are important, because upon them depend the character of plant and animal life and the resulting type of industry. Of all parts of the physical environment, moreover, the soil is most under man's control, and may be modified to meet his requirements to an extent not possible with the form or position of the land, its relief, or climate. It possesses therefore an even greater interest than the other factors.

Nature and relief of the land. — The nature and relief of the land in any country is an important factor in determining the industries and characteristics of the people. One type of soil and one type of relief is suitable to the growth of one crop or the development of a certain industry while another type of earth is better adapted to a different crop or industry. Wheat does not do so well on river bottom land as corn. Tobacco has its particular type of soil, and varying types produce different qualities of tobacco. Rice requires a flat, water-retaining soil. Mining can ordinarily be developed extensively only in rugged regions where erosion has exposed outcrops of the minerals. The development of transportation depends upon relief. Likewise these different conditions of soil and relief develop peculiar characteristics in the people. Mountaineers are unlike the people of the lowlands and plains, and neither is like the desert nomad. People in one-crop or one-industry areas come to view the remainder of the world from the standpoint of their particular kind of work. Thus the nature and relief of the land, in determining occupations and industries, has an influence in shaping the qualities of the peoples found in places of unlike characteristics.

The importance of land. — That part of the environment which supplies our wants for food, clothes, shelter, fuel, business, and tools and equipment is in a broad sense land. Man is dependent upon this environment for everything. His food supply consists of animals and plants, but these are dependent upon the soil. Plants grow out of the soil, man and animals eat the plants, and man eats the animals or food products derived from them, and uses their hides and furs in making clothing, shelter, and industrial equipment. Plants furnish us food, fibers for clothing, materials for shelter and fuel, drugs, medicines, and tools of different sorts. A country is considered good or bad for human habitation in accordance with the abundance with which these different wants are met.

The interest of primitive peoples in the soil is slight compared with that of more advanced peoples in a progressive community. Their interest is in game which depends upon the soil; but as population is generally sparse there is usually plenty. With the rise of agriculture dependence on the soil becomes greater, and with the further development of the arts interest in the crust of the earth increases. Population increases, making necessary more food. The development of agriculture, commerce, and manufacturing calls for the use of more and more agricultural raw materials and minerals. With every step in the advance of civilization the utilization of the earth's resources is augmented.

Processes of soil formation. — The term soil refers to the loose material that covers the solid rock of the earth. It is composed chiefly of ground-up rock and is the result of the forces of disintegration, decomposition, transportation, and sedimentation. In this process, various mechanical, chemical and organic agents give aid. Water, wind, ice, and changing temperatures, acting mechanically, are the chief soil-forming agencies. Repeated expansion and contraction caused by changing temperatures cause the rocks of the earth's surface to become cracked and broken. Water enters these cracks and by freezing there furthers this process of disintegration. The action of wind and rain slowly weathers away the rock and then carries the soil to new locations. Glaciers in passing over the land scrape away the surface of rock and move the particles to new locations and thoroughly mix different kinds of soil.

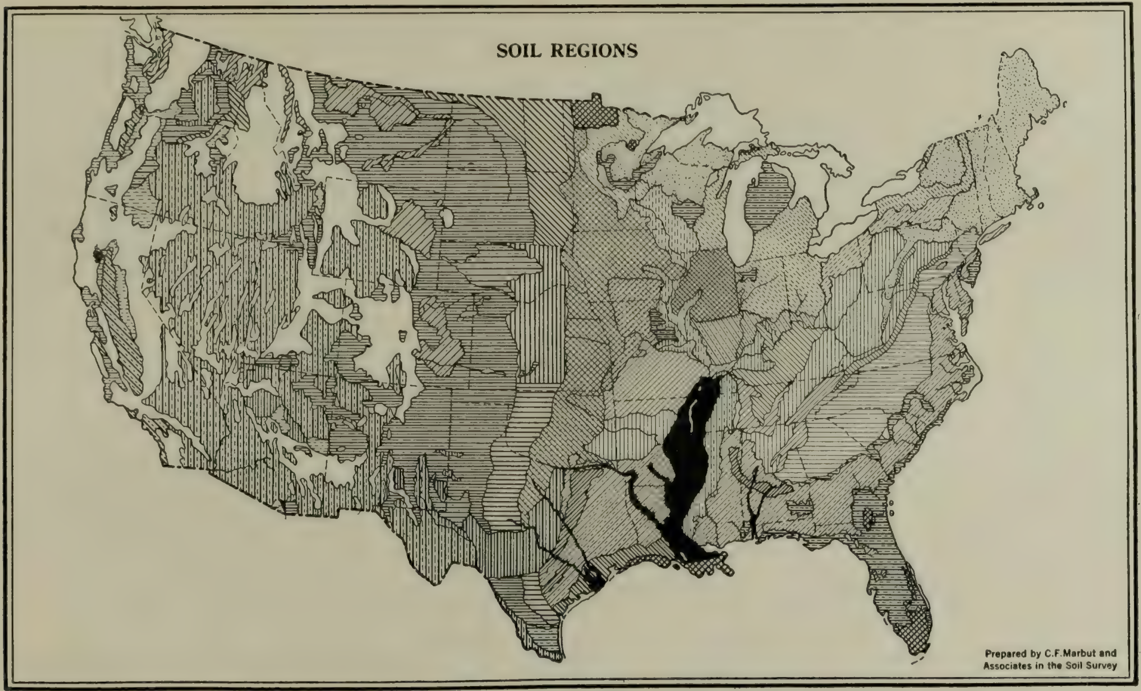
The chemical action of air and water upon the rock is also of significance. They slowly leach away particles of the rock. The water enters cracks in the rocks and as it flows and percolates through becomes better able to carry on the processes of soil formation because of the increasing amount of chemicals in solution which it contains. These chemicals act upon and dissolve particles of the rock.

Plants and animals aid in much the same manner as mechanical agents. Small lichens and moss, plants which derive their sustenance from the air, fasten themselves upon rocks and live and die there; as they die they decay and form soil. Trees and plants also extend their roots into cracks in the rock and break it apart and make easier the mechanical and chemical action of water and wind. Animals and worms in burrowing through the earth pulverize it and expose rocks to the action of air and water.

In the United States — and the same thing is probably true for most of the soils of the world, — 90 per cent or more of the soil has been moved by wind, water, or ice from the original place of formation. During this movement, rock particles of different kinds became mixed, giving generally a more fertile and more lasting type of soil than that composed of only one kind of rock material. River flood plains are always fertile because the soil has come from many different sources and has been thoroughly mixed before being deposited.

Soils transported by different methods and soils from different types of rock material differ as to the rapidity with which they become suitable to plant growth after being deposited.

Types of soil. — Soils may be classified as gravel, sand, clay, and loam. *Gravelly* soil is formed by swiftly running water. It is too coarse for much plant growth, and does not retain water well. Soluble chemical elements are also lacking in sufficient quantity to furnish plant food. Such soil is difficult to cultivate because of the presence of rocks. *Sandy* soils air themselves well and are easy to cultivate but they lack plant food and water-retaining capacity. *Clayey* soils contain a fair amount of plant food but they are sticky and heavy, which makes them hard to plow. They are, moreover, generally poorly drained. The best type of soil is *loam,* which is a mixture of sand, clay, and humus, the latter being



Three broad divisions of soils may be noted in this map: (1) the light-colored arid soils totalling about 500 million acres; (2) the dark-colored grassland soils totalling about 600 million acres; and (3) the light-colored forest soils totalling about 800 million acres.

decayed vegetable matter, which gives to the soil its dark color. It contains plant food in abundance and variety, and is easily plowed, aerated, and drained.

Classified on a broader, more general basis, soils may be called desert, glacial, and moist region soils. *Desert* soils are the most fertile of all. They are wind-blown soils and by reason of being blown about become well-pulverized and mixed. The chemicals all remain in them because there is no water to leach them out and carry them away. If rain does fall in a desert region it sinks a small distance into the soil and is then quickly evaporated. As it is evaporated, the chemicals are held in solution and brought nearer to the surface and left there. The fertility of this type of soil is evidenced by the abundant crops grown under irrigation in dry regions.

Glaciated soils are usually poor, sandy, and often thin, but they hold their fertility well because of being well mixed. Glaciated soils are well adapted to the growth of forests and to pasturage.

Moist region soils, although they may have been fertile originally, usually become poor because the plant foods are leached out and carried away by water. Soils of the torrid zone are very poor on account of this.

Mineral deposits. — The quantity, variety, position, and distribution of minerals have been of great importance in determining human settlements and the development of industries. These materials were used but little by primitive man, as he obtained most of his food and materials from the animal and vegetable kingdoms. The great distinction between primitive and civilized man lies in the knowledge gained by the latter concerning the useful qualities of minerals and methods of obtaining and utilizing them. If the minerals should disappear from the earth modern industry would become impossible, commerce would come to an end, and man would revert to a condition of savagery.

The first mineral used by primitive man as the raw material for tools and weapons was undoubtedly stone; flint and clay deposits attracted settlements and their possession led to constant conflict. Products made from them were in general use and formed the basis of a sort of trade. Salt was another mineral deposit which was highly valued by primitive peoples. A long step forward in human progress was taken when man discovered the use of metals and the age of bronze supplanted the age of stone. Copper was probably the first metal used, because of the ease of smelting and of fashioning it into finished forms. Somewhat later it was discovered that if copper and tin were mixed, the product, called bronze, was much harder than copper alone and hence more useful for either tools or weapons. The greatest advance was made, however, with the discovery of the art of smelting iron and its substitution for bronze. The iron age has to-day given way in turn to the modern age of steel. But at every stage minerals have formed the mechanical bases of civilization.

Using this word in the popular sense, minerals may be divided into the two great groups of minerals proper and of metals. They are of incalculable importance to modern industry, and affect the industrial power of nations in three ways. In the first place they are the materials out of which are manufactured the tools, machinery, and equipment by whose aid industry is carried on. Such are the various machines, the engines and locomotives, steel bridges and office buildings, and similar products. In the second place they furnish the raw materials for certain industries, such as the hardware, pottery, glass, etc. And in the third place power to drive the machinery and carry on the manufactures is derived in large part from the most important of all so-called minerals, namely, coal.

The effects of mineral deposits. — The presence of minerals in a region will cause it to be settled and developed when otherwise it might lie idle for years. The discovery of gold in California in 1849 caused a great rush of people to that state. This exploitation of the region for gold led to its settlement and the development of agriculture, and later to the building of railroads which united it with other parts of the country. The development which has taken place in Southern Africa is due in part to the exploitation of mineral deposits — gold, diamonds, coal, and copper.

A nation with a large quantity and great variety of minerals has an enviable position. If its minerals are well distributed, all parts of the country will in time be explored and developed. The proximity of certain of these minerals to each other is also important. England's industrial advantage lies in the nearness of coal and iron ore to each other. Pittsburgh has become a great industrial center because of the presence there of coal, iron ore, petroleum, and natural gas, and the facilities for land and water transportation.

Many of our present day international conflicts are due to the desire of one country to possess mineral deposits in another. As examples, one may cite the trouble between Chile, Peru, and Bolivia over the nitrate deposits of northern Chile, and the conflict between Germany and France over the coal and iron ore resources of the Rhine region. All industrial nations have been trying to secure oil concessions in the Turkish Empire, and the reason for the control of China from without is the desire of industrial nations to obtain interests in the coal and iron ore deposits of that country.

The influence of physical environment on transportation. — Reference has frequently been made in the foregoing paragraphs to the influence of physical environment upon transportation. In the world of modern industry, with its territorial distribution of occupations, its division of labor and specialization of industry, it is evident that easy and cheap transportation is a prime necessity. Transportation is hindered by every barrier or inequality of surface and is facilitated by the absence or removal of such barriers. Mountains and deserts have always proved the most serious physical obstacles, and have only recently been conquered by the application of modern methods of engineering and construction. Oceans and rivers, which offer far less friction to movement than land, early ceased to be barriers and became the avenues of commerce.

The development of facilities for transporting goods or persons from one region to another has the effect of widening man's environment. In many respects the world to-day may be thought of as a single territory. We are all less dependent upon our immediate surroundings than was the case with our ancestors two centuries or even one century ago. This development of the means of transportation is one method by which natural obstacles may be conquered and the barriers of distance and relief be in part overcome.

Routes of transportation. — Transportation routes are determined in part by the relief of a country. Countries with high mountains and few passes across them are at a disadvantage as compared with a plains country or one with numerous river valleys and passes traversing its mountains. The eastern half of the United States was colonized rapidly because of the ease of getting to the interior through the low Appalachians. If colonization had begun on the western coast, the advance eastward would have been very slow. Europe has the advantage of easy transportation in most parts. There are numerous river valleys and mountain passes, and the mountains are not so high as those of most other continents. In the matter of routes there has been a gradual evolution from the old footpath first to cheaply constructed highways and railroads, and then to our present paved highways and well-ballasted railroad tracks.

The geographical advantages of the United States. — Coming now to our own country we find here a combination of practically all the varied factors described above. On the Atlantic seaboard are to be found broken mountain ranges, short but rapid rivers, fertile soil, and good harbors. The Mississippi basin has a fertile soil, unbroken stretches of level land, an unrivaled system of inland lakes and rivers, and mineral resources. Further inland are the vast plains of the West, and the semi-arid regions of the Southwest, stretching to the lofty mountain ranges of Rockies and the Sierras, rich in mineral wealth but too broken and dry for agriculture. Finally on the Pacific coast are gentle, well-watered slopes. The climate is as varied as the topography. These varied geographical conditions provide the physical basis for the development of a many-sided and diversified civilization.

Man's dependence upon his environment. — At this point it is worth while to remind ourselves of the purpose of this discussion of the physical environment in which man is placed. The object is to make clear the extent to which man is affected and modern industry is influenced by geographical conditions. Subsequent chapters will describe man's action upon the environment, especially the soil and mineral deposits. But in order to understand the development of modern industry it is necessary to understand the conditions under which it must operate and the limitations imposed by those conditions. There are two great factors in human development: the physical universe and man. From one standpoint one may conceive of human progress as an age-long struggle in which man has gradually gained the mastery over nature.

In the early stages man is helpless before nature. His position is that of a servant requiring the aid of a none-too-generous master. But later, by the accumulation of a store of knowledge and by the development of intelligence and energy, he raises himself above these difficulties. Through exploitation and invention, he utilizes the environment to his advantage. Nature is still antagonistic and he is still dependent upon it, but it is a new kind of dependence. Now, instead of being looked upon as a master, nature may be regarded as a servant whose function it is to reward the exertions of man. Man is now the master using the aid of the servant, earth. Increased progress on the part of man develops new classes of wants, and man is continually devising methods by which he may make the earth contribute more fully to his welfare.

The statement is often made that, with the increasing exploitation and control of natural factors, man becomes more independent of his environment. Such a statement is incorrect, although probably justifiable in a sense. Man, in his progress, is not freed from natural surroundings. He multiplies his dependencies upon nature and by increasing the sum total of his relations with nature diminishes the force of each. The connection with nature is wider, broader, and more complex. The bonds are more numerous, but in being more numerous are more elastic. If the food supply of the central African tribes should fail they would likely starve. If the food supply of the United States is short, more can be obtained from other countries. Transportation has made other food-producing regions accessible to the United States, but not to Africa. The colonial inhabitants of Pennsylvania depended upon wood alone for fuel. A present citizen of Pennsylvania has his choice of wood, coal, petroleum, or gas. This does not mean that man is being freed from nature, but only that this dependence has become more far-reaching and less conspicuous and less arbitrary.

Man's command over nature. — Man through his intellect discovers the forces of nature and controls and utilizes them to his advantage. He cannot change these forces, but he can in various ways command them to do his will. Man puts forces in motion and the laws of nature do the rest. Man's part is simply to move, arrange, and combine matter; to avail himself of natural forces already existent or to generate natural forces by the proper arrangement of objects. But the power already existed. Man only puts matter in a position where natural forces can be utilized to greater advantage. He puts seed into the soil and natural forces produce a plant which can be utilized in one manner or another. He puts coal into a furnace, lights it with a match, and heat for warming him or for generating power is the result. Man puts the coal into the furnace and touches the lighted match to it, but the remainder of the process is subject to the laws of nature.

But it is this command of man over nature that has made possible human progress. It is more powerful than natural forces themselves because natural forces do not become effective unless there is some method of utilizing them to advantage. Animals exercise a small command over the forces of nature, primitive man a little more than animals, and civilized man most of all.

Man's struggle with nature. — Man is in a constant struggle with nature, the intensity of the struggle being determined by the unfavorableness of the environment. As has been shown, the struggle is keenest in the tropical and frigid regions. Plants, animals, insects, reptiles, wind, rain, and the sun are his enemies. In the tropics plants are constantly encroaching upon spaces which have been cleared. They grow quickly in fields and soon crowd out the crops if they themselves are not removed. Even in the temperate zone man must fight against the encroachment of weeds upon his crops. Animals and reptiles lie in waiting to attack man or to destroy his crops and animals. Insects attack his crops, livestock, and even his own body, menacing his welfare in various ways. In Africa the tsetse-fly attacks both animal and man and causes the disease known as sleeping sickness. Various species of mosquitoes cause malaria and yellow fever and other diseases. Flies carry typhoid fever germs and rats bubonic plague. Man fears his larger enemies most but these small ones constitute the worst menace. Combating the larger ones is not nearly so difficult as is the fight against these more minute pests.

Then rain, snow, and wind are constantly working against as well as for man. Rain washes the soil from his farm to the sea; drowns his crops or permits weeds to choke out their life; and often in causing floods destroys all that he has. Snow often causes flood; necessitates protection for man and animal; and often by falling late in a season either as snow or as frost, destroys or injures his crops. Wind may destroy his crops, blow away the soil from his farm, or completely destroy, as do tornadoes, his property.

These then are man's enemies. Some exist in one region; some in another. Some are localized; some general. All in all in the course of a year they are responsible for damages amounting to millions of dollars.

The struggle of man against nature as just described is a defensive one, but he also wages an offensive struggle. It is man's province to take advantage of the bounty of nature and this he does in numberless ways, but he must exert his energy in doing so. He avails himself of the products of nature and utilizes them in satisfying his many wants, but he must work to obtain them. In a defensive struggle man must protect himself against those things which would destroy him; in an offensive struggle he draws upon nature or takes from her those things which he considers necessary to his well-being — plants and animals for food and clothing, forests and mineral supplies for shelter, weapons, and tools.

Man's conquest over nature. — But man in his struggle against nature, has not been content to fight single-handed. He has again drawn on his intellect and found various means of exterminating his enemies or of making their effects of less significance. He has discovered sprays for fighting insects which attack animals and plants. Medicines and drugs have offset the attack of germs on his own body. The development of medical knowledge is aiding in conquering the tropics. Gunpowder and traps aid him against animals. He can cut down and destroy weeds and trees, but in this respect his control is not so complete as over insects and animals.

Man builds shelters to protect himself and his domesticated animals against the inclemencies of the weather. He protects his plants and fruit trees from frost by covering or by smudges. He builds dikes to control flood waters and drainage ditches to carry surplus water from his land. Erosion by wind and by water can be controlled in part by the variety of crops grown on the land. In these and numberless other ways man is completing his conquest of nature.

Environment as a factor in progress. — The degree of control which a people exercises over natural surroundings has come to be viewed as the best measure of social progress or civilization. "Of the features which characterize the progressive economical movements of civilized nations," wrote John Stuart Mill, "that which first excites attention is the perpetual and, so far as human foresight can extend, the unlimited growth of man's power over nature." The meaning of this power is well illustrated by contrasting conditions in the United States with those in central Africa. An observer looking out over a broad fertile river valley or plain of the United States sees well-kept farms, large cities, villages, factories, schools, churches, railroads, improved rivers and canals, developed water power sites, parks, museums, telegraph and telephone lines, paved roads, and many other evidences of material progress. In central Africa he would see none of these things. Why the difference? The answer is to be found partly in the character of the physical environment and partly in the character of the peoples inhabiting the two countries. A people can progress only when they are placed in favorable surroundings where they can obtain adequate supplies of food and raw materials, and where the climate and relief promote manufacturing and commerce. In tropical Africa conditions are unfavorable to development while in the United States they are very favorable. The American can win in his struggle against nature, but the African native cannot. And it is this power to subdue and control natural forces, as we have just seen, that lies at the bottom of modern industrial progress.

One must conclude then that man's fate depends in part upon his environment, but in even larger measure upon his intellect. His success is due largely to his ability to adapt himself to conditions which he cannot change, and in lesser degree to his ability to modify these conditions to fit his needs. In his advancement he becomes less dependent upon nature at one point, though he multiplies many times his contacts with nature at other points. But his progress is always determined by the physical conditions and resources which surround him, and will always be limited by his environment; although, by increasing his store of knowledge and by inventions whereby he may bring more forces into subjection to his will, he is constantly forcing back the limits of this environment.

This struggle against his environment has always characterized man's progress, and this conquest of nature by intellect is the epitome of civilization. It proceeds by the utilization of natural forces, but its products are artificial, representing, as they do, the results of man's thoughtful efforts. Modern industry rests upon, but dominates, physical nature.

SUGGESTIVE QUESTIONS

1. Give illustrations showing the effects of different types of soils upon plant life.
2. How are desert soils formed?
3. Would a residual soil be fertile? Explain.
4. Find out to what types of soil our chief agricultural crops are best adapted.
5. See if you can find any cases of erosion of the soil in your neighborhood. Discuss its effects.
6. What type of soil surrounds the building in which your classes are held?
7. Is mineral wealth or a fertile soil more important to a people?
8. Locate the important mountain passes of the United States. What transportation routes go through each one?
9. Compare the United States and Europe as to the ease of land transportation; the United States and Asia.
10. Give illustrations showing how man has mastered and modified his environment.
11. What are the difficulties in the development of land transportation in the tropics?
12. Distinguish between man's offensive and defensive struggle against nature.
13. Ask some farmer to describe his struggle against the destructive forces of nature. Does nature aid him in other ways?
14. What has been done to conquer the diseases of the tropics? (See Publications of the Rockefeller Medical Foundation).

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CHAPTER XIV

PHYSIOGRAPHIC AND ECONOMIC REGIONS OF THE UNITED STATES

Physiographic regions of the United States. — In the three previous chapters have been described the principal physical features of the land in general, so far as they affect man's development. These general considerations may now be applied to the United States in order to determine its suitability as a home for man.

The United States may be divided into seven physiographic provinces[1]: (1) The New England States; (2) the Coastal Plain; (3) the Piedmont Belt; (4) the Appalachian Highlands; (5) the Central Plain; (6) the Rocky Mountain Plateau; and (7) the Pacific Slope. Each of these main divisions in turn contains many subdivisions which are distinguished by their peculiar characteristics of surface, climate, products, and industries.

New England. — New England is largely a highland region, most of which slopes toward the Atlantic Ocean. Once this was an area of lofty mountains, but centuries of erosion have worn these down nearly to sea level. Mt. Washington, 6,293 feet, is the highest peak. The highlands approach very near to the coast and the slope is steep. Most of the mountains and peaks are forest covered. This whole region was glaciated, which accounts for the uneven, rocky surface and poor soil, although there are patches where very fertile soil is found. The numerous lakes were formed by glacial action, which also had much influence on the rivers. The streams are shallow, clear, and rapid, affording in many places excellent water power, which may be considered as the primary factor in the industrial development of New England. Only a few of the streams are navigable and those only for short distances. Mineral wealth, with the exception of building stone, is lacking. The irregular coast produced by subsidence, has favored fishing and navigation. The numerous indentations reduce transportation costs both to and from the interior. Maine alone has about 2,000 miles of fiorded coast line. The climate is continental, due to the fact that the prevailing winds blow across the continent before they reach this area, bringing the high summer and low winter temperatures of the lands at the west. The mean average January temperature of Boston is 27° F., while in the corresponding latitude in England it is 50°. The mean average temperature during the month of July is 72° F. in Boston and only 63° in southern England. The precipitation averages between 40 and 50 inches annually and is well distributed throughout the four seasons.

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[1] See Physical Map of the United States, page 117.

Important agricultural industries are dairying and market and truck gardening, but agriculture is unimportant compared with manufacturing and commerce. Eighty-three per cent of the population of New England is urban. New York state is for the most part similar to New England in physical features.

The Coastal Plain. — This region may be separated into two parts, the Atlantic Coastal Plain and the Gulf Coastal Plain, though each has very similar features. The main difference is a difference of industries, which is determined by proximity to markets rather than by the suitability of certain regions for a particular industry. This plain extends from Long Island to Mexico and averages from 40 miles in width in New Jersey to 100 miles or more in the Carolinas, Florida, and along the Gulf. The whole plain is a continental shelf which has recently been raised from the sea and then has subsided slightly. Therefore it is often so swampy or the soil so sandy as to be unfit for agriculture. Forests are found over sections of this plain. The area contains little mineral wealth, the most important being the phosphate rock deposits of Florida and South Carolina. Due to the subsidence of the land there are many navigable bays and river mouths, but good harbors are found only in the region of Chesapeake and Delaware bays. South of Chesapeake Bay the shore line is more even, the slope gentler, and the offshore waters shallower. There are also many sunken reefs which make navigation dangerous. Because of these conditions, very few good harbors are found. The important cities are found at the head of navigation on bays or navigable rivers or along the fall line where water-power has caused manufactures to develop. The climate is in general mild, and part of Florida has a tropical climate. Precipitation in general is heavy.

Along the Gulf coast the lower courses of streams are tidal.

Shore currents have formed sand bars and islands across their mouths so that few are navigable. Temperatures along the Gulf are high. Snow and frost seldom occur and the growing season is long. Rainfall here averages between 50 and 60 inches yearly except in the Staked Plains of western Texas where it is only 10 inches.

The agricultural industry of the Atlantic Coastal Plain is vegetable and small fruit growing with such crops as rice and cotton where suitable soils are found. In the Carolinas and Georgia textile manufactures are becoming important.

The Piedmont Belt. — To the west the Atlantic Coastal Plain merges into a rough plateau section called the Piedmont, which means foothills. Where the two belts join there has been much faulting of the rocks, which has produced many falls or rapids. This is known as the fall line of the region. The Piedmont region, extending from New York to Alabama, is an uplifted peneplain with a fertile residual soil, favorable climate, and fairly level topography. These conditions make of it an excellent agricultural region. The chief crops grown are cotton and tobacco. Fruits and farm crops of various kinds are also raised. The belt is dotted with towns and cities, the most important being the manufacturing and commercial cities along the eastern edge at the fall line.

The Appalachian Highlands. — This is a long narrow strip of country beginning with the Laurentian Highlands and extending almost to the Gulf of Mexico. It consists of parallel ranges of low mountains separated by narrow valleys through which flow rapid streams. These highlands divide themselves into three groups: (1) the northern, including the mountains of New England and the Catskills and Adirondacks in New York; (2) the central, including the range from southern New York to the Cumberland Gap; and (3) the southern, including all ranges south of Cumberland Gap.

The ranges of the northern section are more broken than those of the others and glaciers have rounded them and taken away most of the soil. Peaks have been formed by glaciers cutting across the ranges. The principal ranges of the central section are the Blue Ridge, the Shenandoah, and the Alleghenies. These ranges are nearly parallel and through them the Delaware, the Susquehanna, and the Potomac cut their way to the sea. The gaps formed by these rivers, together with the Cumberland and Mohawk gaps.

form the principal lines of passage from the eastern seaboard to the interior of the United States. Where the rock of the river valleys is soft they have broadened so as to make an agricultural industry possible. The Shenandoah valley of Virginia and the Tennessee valley are examples. The principal ranges of the southern section are part of the Blue Ridge, the Great Smoky, and the Cumberland. Here the Appalachians reach their greatest height and the ranges are almost uniformly parallel. The highest peak of the whole system is Mt. Mitchell, 6,711 feet in altitude. The climate of the region is variable. In the north there is much snow but in the southern part the climate is mild. The elevation of the mountains is sufficient to cause abundant precipitation.

The region at one time constituted a vast forest reserve of white pine in the northern, hardwoods in the central, and yellow pine in the southern sections. These forests, with the exception of the yellow pine, have been pretty well exhausted. But the mineral resources of the region are almost boundless. Building stones are found in the northern section; slate, coal, petroleum, natural gas, and iron in the middle; and marble, coal, iron, and phosphates in the southern. These mineral resources have been the cause of the prosperity and growth of cities in the Appalachian Highlands.

The Central Plain. — The Central Plain naturally divides itself into three parts: (1) the Prairie region, (2) the Great Lakes region, and (3) the Great Plains.

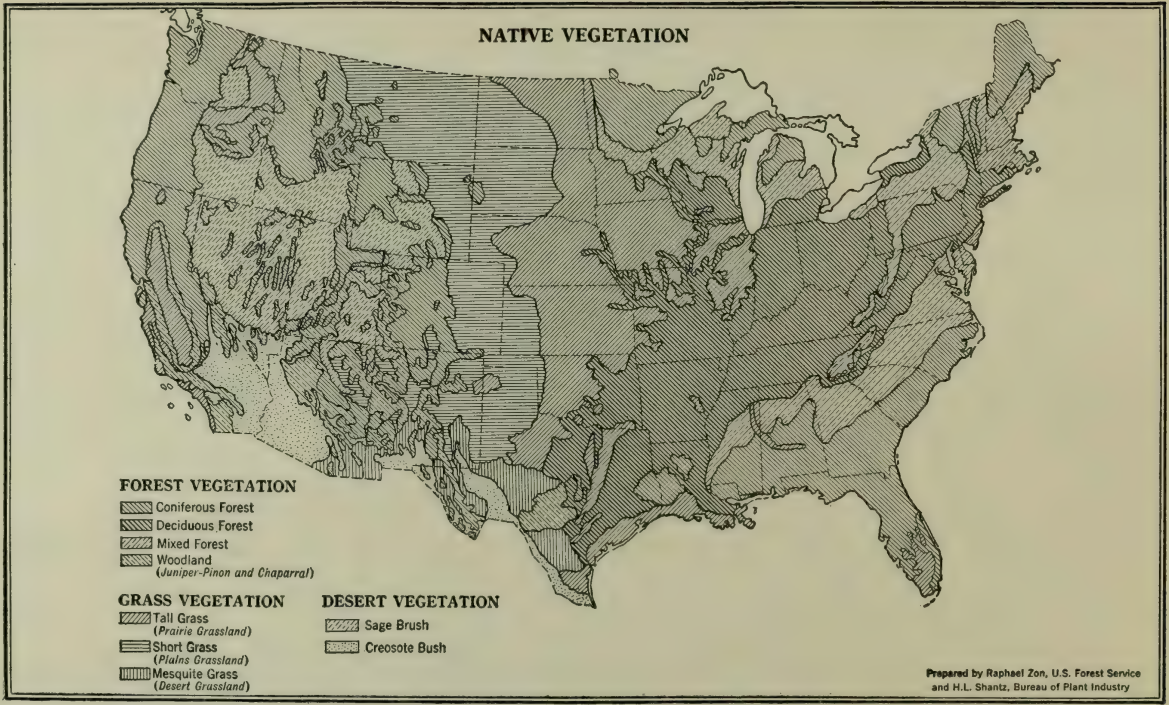
The Prairie region embraces all of the most fertile portion of the Mississippi basin. It extends from the western slope of the Appalachian to the Great Plains and from the Great Lakes and Canadian boundary to the northern boundary of the Gulf plain. The only important breaks in elevation are the Ozark Mountains, the Black Hills, and the highlands of the Lakes region. The region is practically treeless, free from stones, and has a deep fertile soil. With its excellent climate and good rainfall, the region is well adapted to the raising of crops on a large scale, and it forms the most important agricultural region of the world. It sustains a large population and ships products to the industrial parts of the United States and to Europe.

The whole Central Plain has a continental type of climate with great extremes of temperature and precipitation. The prevailing wind, the westerly, brings the high summer and low winter temperatures of the areas to the west. In the Prairie region precipitation decreases from south to north, being about 40 inches per year in the southern and 20 inches in the northern part. It is fairly well distributed as to months, the minimum coming in late summer, which is an advantage to ripening grain. Snowfall and frost are common in the northern and central parts of the area. This region has good coal, iron, and petroleum resources. There are also numerous waterways navigable for small craft.

The basin of the Great Lakes blends so gradually with the Prairie region that it is difficult to find the dividing line. From the Prairie region the Great Lakes region extends northward into Canada. This region was glaciated and resembles in many respects the New England region. The land is more rolling and uneven than the prairies and much of it was originally covered with forests. Enough of these forests still remain to make a thriving lumber industry in several localities. Because of the even climate, fruit raising is important in Michigan, and the glaciated soil and nearness to large cities causes dairying to be an important industry. The growth of hay and forage is also important. Other crops are produced in varying quantities. The region is rich in iron ore and has considerable copper. The lakes also form an extensive water route and many towns established on their borders have grown to large cities. In both this and the Prairie region, manufacturing is important.

The Great Plains include the foothills of the Rocky Mountains and extend eastward to about the 100th meridian. In this area rainfall is deficient, being less than 20 inches per year, the minimum amount necessary for agriculture. The agricultural industry has, however, been of increasing importance in this region during the past few years because of dry-farming methods and irrigation. Before this only the land along river valleys was farmed. The region is a fairly level plain with good soil. Grazing is the chief industry, although along the eastern edge a great deal of wheat is grown. Mineral deposits in this area are not important.

The Rocky Mountain Plateau. — The Rocky Mountains have as their base a plateau of about 5000 feet elevation which merges with the Great Plains on the east. The ranges of this system extend from northwest to southeast. The plateau is widest along the line that forms the boundary between Colorado and Wyoming and its western slope is much more precipitous than the eastern. Several mountain ranges extend across the plateau and divide it



Prepared by Raphael Zon, U.S. Forest Service and H.L. Shantz, Bureau of Plant Industry

Forests originally covered about 900 million acres in the United States. About 350 million acres have been cleared for agriculture and as many more have been cut-over. About 600 million acres were clothed originally with grass. Some two hundred million acres of this grassland have been used for crops or for pasture. Desert vegetation characterized 400 million acres, of which about 12 million acres have been reclaimed by irrigation.

into three well defined regions: the Columbia Plateau, the Colorado Plateau, and the Great Basin.

The Columbia Plateau includes most of Idaho, Washington, and Oregon and has the best climate for the growing of wheat of any region in the United States. With the exception of the eastern portion it is well watered and the climate is not severe.

The Colorado Plateau includes a small part of Nevada, most of Colorado, and a portion of Utah, Arizona, New Mexico, and California. The whole region is arid or semi-arid. It contains many high peaks, deep canyons, and swift streams fed by melting snows. The soil is fertile and the region would be very productive if it had sufficient rainfall. Abundant crops are raised in irrigated sections, especially in California, Arizona, and New Mexico.

West of the Colorado Plateau and south of the Columbia Plateau, and between the Rocky Mountains on the east and the Cascades and Sierra Nevadas on the west, is a plateau desert area known as the Great Basin, so called because none of its rivers drain out to the ocean, either losing themselves in the sands or emptying into lakes. Practically all of Nevada and Utah, the Death Valley area of California, and a portion of Oregon are included within its area. It is a rough region with fertile soil, but with little agriculture except where irrigation is possible. The aridity is due to the fact that the mountain ranges of the Pacific coast shut off the rainfall. As the winds come up the west slope of those mountains they become cooled and deposit their moisture on that slope. When they come over the mountains they start to descend, thus becoming warmer, and gradually take up moisture rather than give it off. Several ranges of mountains are found in the basin, the chief being the Wasatch and the Uintas. Temperature is variable. In the northern part snows and cold weather are common and some of the mountain peaks are covered with snow at all times. As one goes south the temperature becomes milder until in the extreme southern part mild winters are the rule.

The great altitude of the Rocky Mountain Plateau gives it a cool climate in general throughout the year, but the rainfall, except in river valleys, is not sufficient for agriculture. In most of the valleys the soil is fertile and under irrigation bountiful crops are grown. There are also extensive pine forests in the region, but they are too far from market and too inaccessible to be used at present. Pasture for grazing is also abundant. The great wealth of the region lies in its store of the more valuable minerals, gold, silver, and copper being the most important. Iron and coal resources are also present and are leading to the location of iron and steel mills near the larger cities. Navigable rivers are lacking, but the rough topography, the many mountain-streams, and the glaciers provide a great deal of available water power which may be utilized both for irrigation and for the development of electric power.

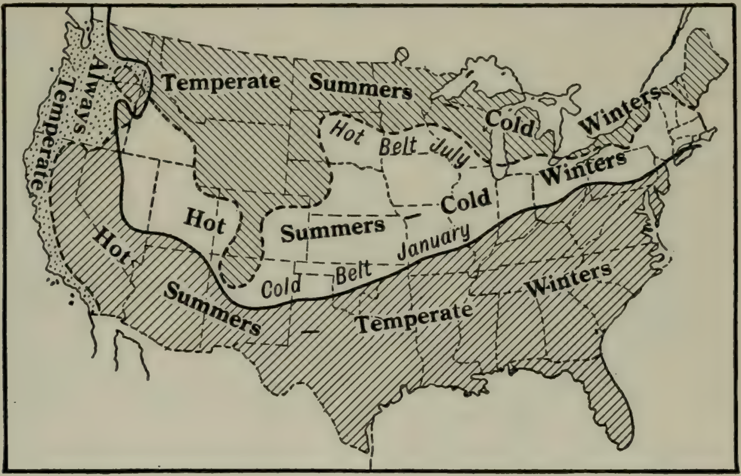
The Pacific Slope. — This is a region of lofty mountains, some with perpetual snow, with intervening river valleys which constitute some of the most fertile farming country to be found anywhere. The most important of these valleys are the Sacramento and the San Joaquin in California, the Willamette of Oregon, and the Wenatchee of Washington. The mountain ranges are the Coast Ranges which rise abruptly from the sea-coast, and east of these the Cascades, in Washington and Oregon, and the Sierra Nevadas in California. The central valley of California, which lies between these ranges, is 400 miles long and about 50 miles wide. The waste of the mountains has been washed into this valley for ages, building up a large area of fertile land. Wells have been drilled in it to a depth of 3,000 feet without striking bedrock. The mountains here are the highest in the country, many of the peaks attaining an elevation of 15,000 feet.

Due to the influence of the ocean this region has a mild climate, that of parts of California being subtropical in its nature, and, because of the high mountains to the west, the whole region is well watered, the northern section receiving 60 inches or more annually. Navigable streams are scarce, but potential water power resources are very abundant. The coast line is very regular and good harbors are not so frequent as on the Atlantic Coast. Puget Sound, the Columbia River, and San Francisco Bay, the latter connected with the ocean by the Golden Gate, afford the best and most important harbors because of their protected locations. Los Angeles has also developed an important artificial harbor at San Pedro.

The chief agricultural pursuit is fruit and vegetable growing. The abundant rainfall is responsible for a large lumber industry. The more valuable minerals also exist in good quantity.

The climatic regions of the United States. — Climate embraces temperature and moisture, and on the basis of each of these climatic factors certain distinct regions may be distinguished, each with its own characteristics. It will be noticed, however, that the temperature belts do not coincide with the rainfall belts.

On the basis of temperature the country may be divided into four climatic regions, as follows: (1) a region characterized by temperate summers and cold winters; (2) a region characterized by hot summers and cold winters; (3) a region characterized by hot summers and temperate winters; and (4) a region which is always temperate. These regions are shown on the accompanying map.



Climatic Regions

In the first two of these regions, especially in the northern part, the weather is subject to great and sudden changes of temperature, caused by cyclonic storms that cross the country from west to east. Thus the temperature range in North Dakota is 150 degrees, while in Key West it is only 59 degrees. The changes in temperature are of chief moment in their effect upon agriculture, and here the most important consideration is the length of the growing season. This is determined by the date of the last frost in spring and of the earliest one in autumn. The length of the growing season determines in large part the crops which can be grown within particular areas. At Phoenix, Arizona, the last frost is usually about February 23 and the first about December 3, giving a growing season of over nine months; at Augusta, Georgia, the dates are March 13 and November 15; in central Vermont, May 15 and October 15; and in North Dakota, May 15 and September 15. In this last instance the growing season is restricted to only four months. If frosts come later in the spring or earlier in the fall than is usual, great damage is often done to growing crops.

The country may also be divided into various climatic regions according to rainfall, but all of these may be reduced to two, the humid and the arid, between which there is a neutral belt known as semi-arid. These are shown for the United States in the map illustrating the Agricultural Regions.

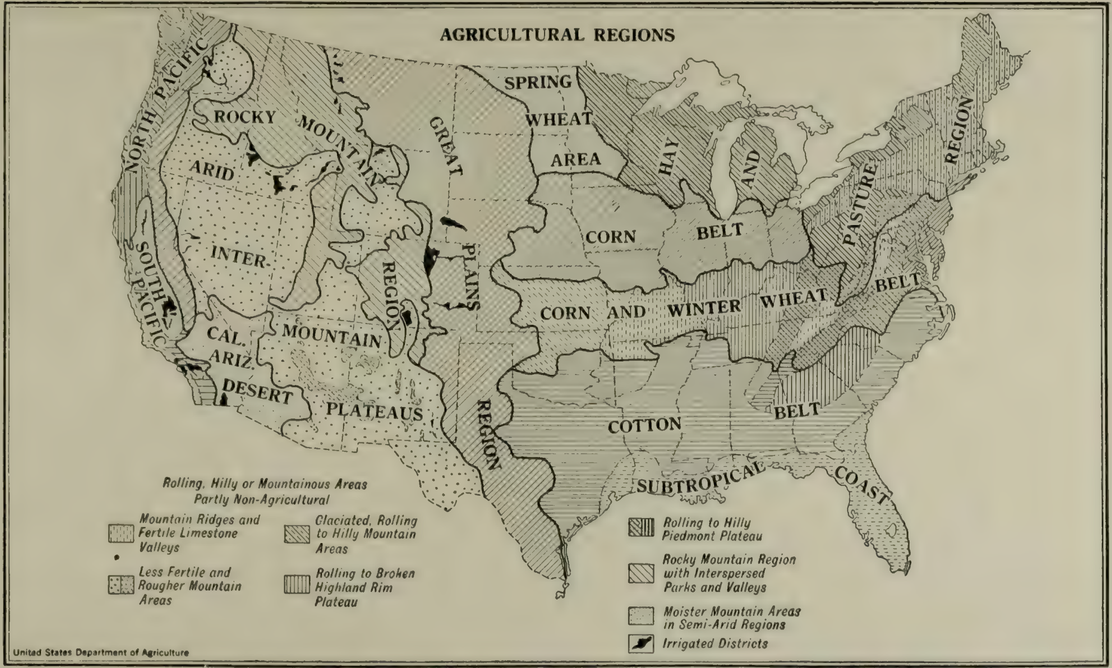
The arid belt stretches from the Pacific Coast east to about longitude 100°, with the exception of the Pacific slope, which is humid. This region has an average annual rainfall of less than 15 inches, and over large areas of less than 10 inches. Such a scanty rainfall means scanty vegetation. Crop production cannot be carried on except where irrigation is possible, but grazing is the leading agricultural occupation. Population is necessarily sparse, because of the absence of a natural basis for extensive settlement.

In the semi-arid belt, which lies roughly between longitude 96° and 100°, the yearly rainfall is between 15 and 20 inches. It is a region of grass land, as there is not enough water for most cultivated crops, though some drought-resistant grains, like durum wheat, can be made to grow. Grazing is a leading agricultural occupation, and the population is somewhat denser.

The humid belt covers the remainder of the country east to the Atlantic Coast. There is everywhere an abundance of rain to grow crops, although the average annual rainfall varies considerably. The greatest cereal districts of the world lie in this region, and a little to the south lies the greatest cotton-producing area. It is the region of greatest development in the United States, having the major part of the population, most of the important cities, and showing the greatest activity in manufacturing, commerce, and transportation.

The agricultural areas of the United States. — The United States may be divided into six regions on the basis of the predominating type of agriculture followed. (1) The first region comprises the New England States and New York. Dairying, mixed farming, and vegetable growing are the principal lines followed.

(2) Next, is the corn and winter wheat belt which follows the


AGRICULTURAL REGIONS
NORTH PACIFIC
SOUTH PACIFIC
ROCKY MOUNTAIN REGION
ARID
INTER-MOUNTAIN
CAL.
ARIZ.
DESERT
PLATEAUS
GREAT PLAINS REGION
SPRING WHEAT AREA
HAY AND PASTURE REGION
CORN BELT
CORN AND WINTER WHEAT BELT
COTTON BELT
SUBTROPICAL COAST
Rolling, Hilly or Mountainous Areas Partly Non-Agricultural
Mountain Ridges and Fertile Limestone Valleys
Less Fertile and Rougher Mountain Areas
Glaciated, Rolling to Hilly Mountain Areas
Rolling to Broken Highland Rim Plateau
Rolling to Hilly Piedmont Plateau
Rocky Mountain Region with Interspersed Parks and Valleys
Moister Mountain Areas in Semi-Arid Regions
Irrigated Districts
United States Department of Agriculture

The United States may be divided into two parts, equal in area, the East and the West. The East has a humid climate, the West mostly an arid or semi-arid climate, except the North Pacific coast and the higher altitudes in the Sierra, Cascade, and Rocky Mountains. Each of these two parts has been subdivided into six agricultural regions, characterized by distinct combinations of crops or systems of farming, the result largely of the different climatic conditions.

37th parallel to the eastern edge of Colorado as a southern boundary, the eastern boundary of Colorado and Wyoming to the northern edge of Nebraska and from there eastward to Lake Michigan. Dairying, stock feeding, and fruit and tobacco raising are also important in certain sections. Most of the wheat is produced in the western one-third of this region and most of the corn in the central one-third.

(3) The cotton belt has within its boundaries all of the states south of the 37th parallel and east of the western boundary of Texas. This has been largely a one-crop region, but livestock, corn, wheat, rice, tobacco, fruits, and vegetables are being grown to an increasing extent.

(4) The fourth region is the spring wheat belt which contains the Dakotas, Minnesota, most of Wisconsin, and a strip of northern Iowa. Although there is some variety of crops this is largely a one-crop region, with extensive dairying in Minnesota and Wisconsin.

(5) West of the spring wheat, the corn and winter wheat, and the cotton belts, and including all the western states except Washington, Oregon, and California, is a region given over largely to grazing. Here, wool and meats are the chief products.

(6) In Washington, Oregon, and California wheat and fruits are the important products. In eastern Washington and Oregon and central California wheat is grown, and in sheltered valleys throughout the whole region fruits of varying degrees of resistance to frost are found.

The crops which are produced in any given area are influenced both by physical and economic conditions. In the first place, soil and climate determine the adaptability of crops to certain regions. Although physical limitations are often strict, several products can generally be grown on the same land. If such is the case, economic conditions determine the crop to be grown. The most profitable one will be the one selected and profitableness is determined largely by markets; so the location of markets for a product is usually a determining factor in the growth of agricultural commodities.

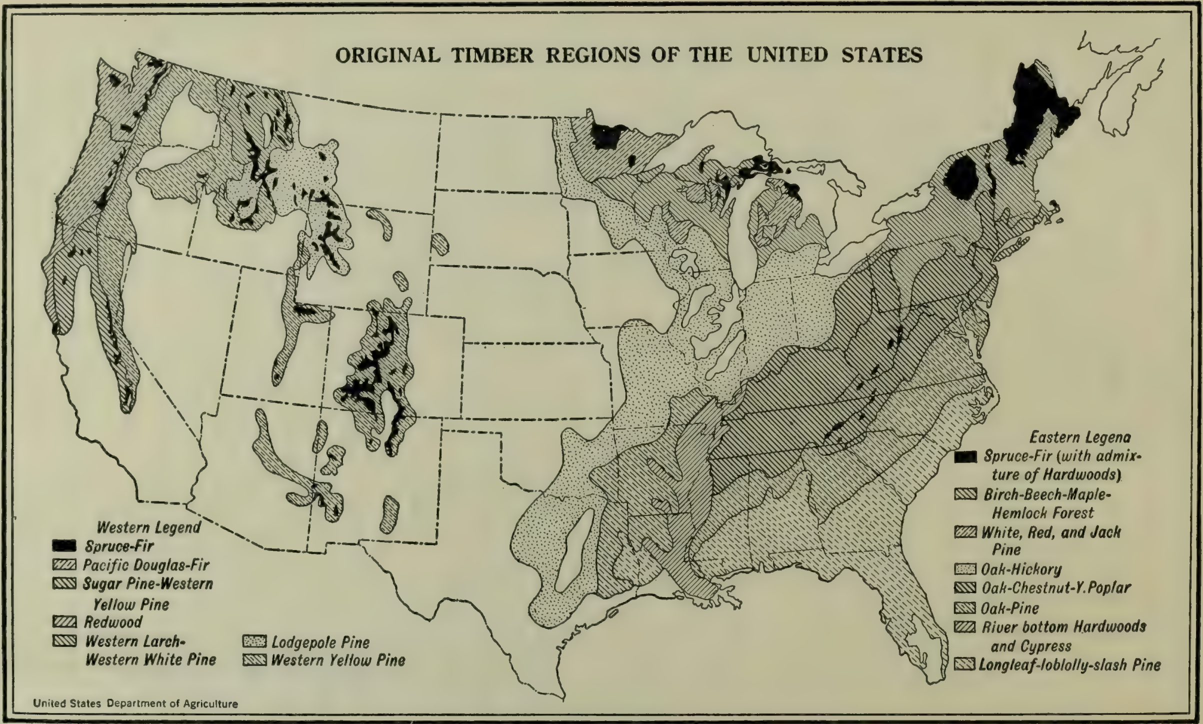
Mineral areas of the United States. — There are three mineral areas in the country: (1) the Appalachian Highlands, containing vast quantities of the baser minerals and fuels; (2) the Great Lakes region, containing large deposits of iron ore and copper;

and (3) the Rocky Mountain Plateau, containing practically all minerals known, but possessing particularly large stores of the precious metals. These regions are unsuited for any other industry on a large scale than mining, except timber culture. The plains region contains deposits of coal and petroleum, but agriculture is of chief importance. As these are treated more fully in the following chapters, no further discussion is necessary here.

The forest areas of the United States. — Forests are usually found in regions having sandy and loamy soils and an abundant supply of moisture. They are not ordinarily found in regions having less than 30 inches of rainfall, and the best forests occur in regions having 50 inches or more.

The natural forest region of the United States comprises all of the territory east of a line running almost due north from the mouth of the Rio Grande; and also the higher parts of the Rocky mountains, and the western slopes of the mountains of the Pacific coast. At one time these regions were entirely covered with forests, but due to settlement, lumbering, and fires a great proportion of them has been exhausted. Using the lumbering industry as a basis, the forests of the United States may be divided into seven districts: (1) the New England and Adirondack, (2) the Great Lakes, (3) the Appalachian Highlands, (4) the Hardwood, (5) the Southern, (6) the Rocky Mountain, and (7) the Pacific Slope.

New England and Adirondack forests. — This region covers all the northeastern United States and extends far to the north into Canada. The most important tree is the white pine, followed by spruce and hemlock in the order given. Along the southern edge of the area, maples, beeches, birches, chestnuts, and oaks are found. White pine is prized because of its strength, lightness, durability, and the ease with which it can be worked. It has been used so widely as a building material that the supply is becoming exhausted. The original area of the district in the United States, including the Great Lakes area, was 150 million acres, containing 1000 billion board feet of lumber. Of this vast amount only 40 per cent remains. This district was the first important lumbering center in the country because of the early settlement of the population in New England, the value of the trees, and the ease of getting the logs to a mill, the large amount of snow and rain and large number of streams making easy the hauling of the logs from the forest and floating them to the mill.


ORIGINAL TIMBER REGIONS OF THE UNITED STATES
Western Legend
Spruce-Fir
Pacific Douglas-Fir
Sugar Pine-Western Yellow Pine
Redwood
Western Larch-Western White Pine
Lodgepole Pine
Western Yellow Pine
Eastern Legena
Spruce-Fir (with admixture of Hardwoods)
Birch-Beech-Maple-Hemlock Forest
White, Red, and Jack Pine
Oak-Hickory
Oak-Chestnut-Y. Poplar
Oak-Pine
River bottom Hardwoods and Cypress
Longleaf-loblolly-slash Pine

United States Department of Agriculture

The original eastern forests formed 83 per cent and the western 17 per cent of the total. Of our present forest land the East has 75 per cent and the West 25 per cent. But the West now has 61 per cent of the remaining saw timber supply.

Great Lakes forests. — This district is only a continuation of the New England district, climate, soil, and the principal types of trees being the same in both. Lumbering developed here when the westward movement of population took place. Because of the great depths of snow found in this region during the winter months, the logs can be taken from the forests to streams and railways with but little difficulty. The lumbering industry of this region dovetails with the grain industry, the men working in the lumber camps in winter and in the harvest fields during the summer months.

Appalachian Highlands forests. — This district extends from southern New York to northern Georgia and Alabama along the Appalachian Plateau. The elevation of this area extends the temperature and therefore the trees of New England far to the south. Throughout the region hemlock has been an important tree. Lumbering is more difficult than farther north because of the steep slope of the mountains and the small amount of snow. The logs are either hauled out on wagons or slid down chutes of logs or steel to a railway. The proximity of this district to the industrial section of the country, together with the good qualities of the lumber produced, has resulted in the practical exhaustion of the timber of this area.

Hardwood forests. — Hardwoods grow at the lower altitudes throughout the central part of the United States, beginning with the Atlantic coast and expanding to the north and south as the prairie states are reached. The region stretches from New York to Alabama and westward as far as the Ozark Mountains and the Great Lakes. This region is the home of the finest, largest, and greatest variety of hardwoods to be found anywhere in the world. The most popular trees are oak, ash, beech, walnut, hickory, chestnut, yellow poplar, basswood, cottonwood, sycamore, gum, cherry, and maple. Of these oak, chestnut, and hickory lead in use. The chief producing states are West Virginia, Kentucky, Tennessee, and Arkansas. Memphis is the greatest hardwood market in the world; Chattanooga and St. Louis are also important. This forest region probably covered an area of 280 million acres, containing about 1,400 billion board feet of lumber, originally, but to-day about 18 per cent of that amount is all that remains. This forest district occupied the rich agricultural parts of the country, and consequently large areas were deforested in clearing the land for agricultural use.

Southern forests. — The depletion of the white pine forests about 1890 caused the lumbering industry to shift to the southern states, where there are abundant quantities of yellow or hard pine. This is very desirable for flooring, wainscotting, and for building railway cars. The district begins along the sandy sea coast of New Jersey and follows the coast around the southern end of the Appalachians, and then goes westward as far as Austin, Texas. Along the Gulf coast the district extends northward into Oklahoma and Arkansas. Other trees of the region are cypress, gum, some hardwoods, and the old field pine, which is one of the fastest growing trees of the United States. The climatic conditions found in the southern pine region make it one of the best places for trees to replace themselves if they receive the proper care. Lumbering is much easier than in the mountain districts but often swamps and rainy weather offer difficulties. Teams and donkey engines pulling a cable draw the logs from the forests to railways. Here they are loaded and sent direct to a mill or to a stream upon which they are transported to a more distant plant, where they are manufactured for coastwise and foreign trade. Gulfport, Mississippi, is the greatest lumber-shipping point in the world, though many other ports in this region also ship out lumber.

Cypress is an important tree of this region. It grows in swamps, and when the trees fall over the peat and water of the swamp preserve them, forming the fossil cypress which is used for interior work in dwellings. The lumber is used for shingles and makes a good substitute for white pine. The Dismal Swamp, Florida, and the area around New Orleans have followed each other as the chief cypress-producing regions.

The original area of the southern pine region was about 220 million acres, containing 1,000 billion board feet of lumber. About 20 per cent of this remains to-day.

Rocky Mountain forests. — In the southern part of this region trees grow only upon the high plateaus, but farther to the north, in Idaho and Montana, lessened heat and evaporation permit trees to grow at lower levels. In general the trees of this region are tall, straight, of small diameter, and practically all conifers. Scattered patches of poplar and white birch are found. In the southern portion the Western yellow pine is of most importance.

Farther north, spruce, Douglas and white fir, larch, lodgepole pine, Western hemlock, Western red cedar, and Western white pine are cut. Much of the timber of this region is inaccessible to ordinary means of transportation, so flumes with water flowing through them are built to carry the logs to the mills. These are often miles in length. The principal use of this forest has been for lumber, poles, and railroad ties. This forest area originally covered an area of about 110 million acres with 400 billion board feet of lumber. Of this amount some 55 per cent still remains. A great deal of the depletion has been due to forest fires, which, because of the dryness of the region, do more damage than in any other forest area.

Pacific Slope forests. — The forests of the Pacific Slope are the finest in the world. In eastern forests an acre produces from 4 to 10 thousand board feet of lumber, but in this region 100 thousand feet are common and small areas of very large trees yield as high as 5,000 thousand feet. The chief trees utilized are redwood, Oregon pine, and Douglas fir, which grow from 4 to 10 feet in diameter, with straight trunks 100 feet or more in length. The size of the logs is so great that it causes difficulty in handling and working them up. The vast size of the trees is due to an even climate, heavy rainfall, and a freedom from windstorms. The original area of the Pacific Slope forests was about 90 million acres containing 1,400 million board feet of lumber. About 80 per cent of this amount is still standing. Fire has done considerable damage in this region, especially in the Douglas fir region of Washington and Oregon, where 30 per cent of the original area has been devastated.

Benefits of forests. — The influence of forests upon the water supply of a region is very great. The large areas of roots and leaves are important in regulating and increasing the amount of moisture in the atmosphere. The roots of a tree draw water from the soil, which is finally given off by the leaves in the form of vapor. An ordinary sized elm has about 7,000,000 leaves which expose to the air a surface of about 5 acres, and in 12 hours of clear dry weather these leaves give off about 7¾ tons of water. When we consider all of the trees in existence the amount of water given off daily becomes almost incomprehensible.

The soil of a forest has great water-holding capacity because of its porosity and because of the heavy covering of leaves, twigs, and decayed vegetation. After a heavy rain much of the water is absorbed by this forest floor and allowed to flow into the streams gradually. Where forests have been cut away streams become flooded easily, often doing serious damage in the lowlands. This regulation of the flow of water is important in navigation, irrigation, and the development of water power.

On hillsides forests prevent erosion. Many regions have lost all of their good soil after forests have been cut. This soil when carried to lowlands often does a great deal of damage by spreading itself over better soil or covering up crops.

The presence of forests is a factor in modifying the extremes of local climate. They act as windbreaks and check the extreme effects of both high and low temperatures.

In addition to these functions forests serve as recreation grounds, as homes for birds and wild animals, and as beautifiers of the landscape.

SUGGESTIVE QUESTIONS

1. Why can dairying and horticulture be carried on so advantageously in the New England states?
2. Describe the continental type of climate.
3. Why are large amounts of vegetables grown in Texas?
4. Locate on an outline map the mountain ranges and important mountain peaks of the United States.
5. Explain the origin of San Francisco Bay and the Golden Gate.
6. Why is wheat grown so extensively in the Great Plains regions?
7. Why does Iowa lead in the production of hogs?
8. Why is there but little corn grown west of the 100th meridian?
9. What obstacles to agriculture are encountered in each of the agricultural regions of the United States?
10. What are the leading states in the production of lumber? (Statistical Abstract of the U. S.)
11. Show on an outline map the different agricultural, mineral, and forest regions of the United States.
12. Study the relief map of the United States and then write a description of the country in your own words.
13. Would you rather live in a picturesque but infertile region, or in a physically monotonous but fertile region?
14. Is the presence of the Appalachian Mountains advantageous, or the reverse? The Rocky Mountains?
15. Why did the early settlers cut down the forests? Is it likely that this motive will lead to further reduction of the forest area?

BIBLIOGRAPHICAL NOTE

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CHAPTER XV

MINERAL RESOURCES: THE MINERAL FUELS

Utilization of minerals. — Man's progress has been marked by his conquest successively of the animal, vegetable, and mineral kingdoms. First a hunter and fisher, and then a nomad herdsman, he long depended upon animals for his sustenance. In the next stage man became an agriculturalist and cultivated grains and vegetables and fruits. The exploitation and utilization of the varied treasures of the mineral kingdom called for greater intelligence and more complicated processes and marked the last step to be taken. The use of stone and clay, of copper and iron, has long been known, but the vast storehouse of mineral resources was not fully utilized until the use of coal, about the middle of the eighteenth century, unlocked the door. Probably the most marked contrast between the economy of the savage and that of the European or American to-day is to be found in the greater use by the latter of mineral resources, expecially of coal and iron.

Abundance, variety, and distribution. — Fortunately for the human race minerals exist throughout the world in abundant quantity, great variety, and in widely distributed locations. The existence of the essential minerals is of fundamental importance in the economic development of any country. Modern industrialism, for instance, is unthinkable in the islands of the South Pacific, which lack both coal and iron. On the continental land areas there are large stores of mineral wealth, but these are not illimitable.

Of almost greater significance than the existence of minerals is their unequal distribution over the earth. In this fact is to be found in large measure the explanation of the uneven industrial development of different countries. Modern industry, which is based upon coal and iron, has shown its greatest growth in those localities most favored in the supplies of these minerals. China seems to be an exception to this rule. The three great industrialized regions of the world to-day are the eastern part of the United States, Great Britain, and the valley of the Rhine; and in these three areas abundant supplies of coal and iron are found in close proximity to each other.

On the other hand, the restriction of certain desirable minerals to particular localities has often led to conquest and war. Thus the leading European nations have appropriated the territory in northern Africa for the sake of the mineral wealth located there, they have sought the partition of China, and are quarreling over the oil fields of Persia and Mesopotamia. Limitation of mineral resources has political consequences as important as the economic results of abundance. The possession of adequate mineral resources by nations capable of utilizing them, makes these the industrial leaders of the world; while the presence of desirable supplies in non-industrial countries exposes them to the rapacity of their more powerful neighbors.

Classification of minerals. — Minerals may be classified according to use or according to composition. In a classification according to use they are divided into (1) mineral fuels and (2) minerals employed as raw materials in manufactures. In the former group are coal, peat, petroleum, and natural gas; in the latter are iron ore, and the ores from which aluminum, lead, zinc, tin, gold, silver, sulphur, and a large variety of minor minerals are derived.

In a classification based upon composition minerals are called either metallic or non-metallic. Those in the second group above, with exception of sulphur, are metallic, while the non-metallic minerals include the mineral fuels, building stones, and clay. For the purposes of this book the classification based upon use is of more significance and will be followed.

Importance and uses of coal. — Of all minerals coal is the most important and the least dispensable. This fact was stated over fifty years ago by W. S. Jevons: [1]

" Coal in truth stands not beside but entirely above all other commodities. It is the material energy of the country — the universal aid — the factor in everything we do. With coal almost any feat is possible or easy; without it we are thrown back into the laborious poverty of early times."

Coal may be used to develop power, to heat buildings, or as a raw material of manufacture. The proportion of anthracite and bituminous coal mined in the United States in 1915 which was applied to each of these uses, is shown in the following table: [2]

[1] *The Coal Question* (London, 1865), p. 2.

[2] *United States Geological Survey,* 1916.

Coal used at the mine for pumping, etc.	3.9	per cent
for locomotive fuel	25.6	" "
for steamer fuel	2.2	" "
for manufacturing power	31.5	" "
for heating buildings	23.8	" "
for making coke	12.1	" "
for illuminating gas	0.9	" "
Total	100.0	

The first four uses were for the generation of power and required 63.2 per cent of all the coal; heating called for 23.8 per cent, and manufacturing 13.0 per cent. These figures show roughly the relative importance of the different items in the United States. About half of the coal used to develop power went into the transportation of commodities, including the coal itself, and the other half was for use in manufacturing establishments.

Composition and combustion of coal. — Coal is composed of the combustible or pure coal, and of ash, moisture, and other non-combustible components. The excellence of a coal for heating purposes manifestly depends upon the proportion of combustible to non-combustible materials. When coal is burned the non-combustible materials are discharged in the form of gases and vapors, but these interfere with the free burning of the carbon and tend to lessen the amount of heat available. It is necessary to heat the atmosphere to such a point that the volatile elements will be consumed, and also to furnish sufficient air to combine with the carbon in the coal so that this will burn freely. Unless this is done the combustible materials are not burned, but escape as smoke through the chimney without supplying any heat. Smoke is therefore always a sign of poor combustion. To supply the proper amount of air is difficult in burning soft coals, because they almost immediately form a cake and crust over the top when thrown upon the fire. In burning soft coal, a strong current of air is necessary, which must be furnished to the combustion chamber above the fuel bed as practically no air can come through this. Hard coals, which will stand up under weight and burning, and allow a free circulation of air, are much better.

Classification of coals. — The coals form a completely graded series from peat to graphite, but graphite is not used as a fuel. The usual classification is peat, lignite, sub-bituminous, bituminous, semi-bituminous, semi-anthracite, and anthracite. They may be graded according to their heat values, taking as the unit the amount of heat necessary to raise 1 lb. of water through 1° F., which is known as a British thermal unit. On this basis we obtain the following table:

CLASSIFICATION OF FUEL BY HEAT VALUES[3]

	B.t.u.
Peat	7,800–11,500
Lignite	11,500–13,000
Sub-bituminous	13,000–14,000
Bituminous	14,000–15,000
Semi-bituminous	15,000–16,000
Semi-anthracite	15,500–16,000
Anthracite	15,000–15,500

Peat. — The first step in the formation of coal is the production of peat, which can be utilized as fuel when dried. There are many places in the world where it is cut in blocks and dried in the sun and then burned as a fuel, chiefly for heating houses. It is also used to a small extent in the manufacture of paper. In Ireland and Sweden, where peat bogs cover a large area of the country, it is important as a domestic fuel. In the United States there are 11,000 square miles of peat bogs, and in Alaska there are beds which are estimated to have a product of 13,000,000,000 tons of fuel when dried. From the Great Lakes northward in Canada stretches a large peat bog, and much of the tundras of northern Europe is a peat bog. Supplies occur in smaller quantities in practically every country of the world. Large as the supplies are, they would last only six or seven years if they were substituted for coal.

Lignite or brown coal is woody in texture and disintegrates easily on exposure to the air. Often trunks of trees are found imbedded in the strata. It is a poor fuel, containing often as much as 30 per cent water, while good coal has only 5 or 6 per cent; it also contains from 40 to 50 per cent of volatile matter, and only a small amount of carbon. It can be made into briquettes and used for domestic and some other purposes, but not in metallurgical works.

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[3] S. W. Parr, *The Analysis of Fuel, Gas, Water, and Lubricants* (New York, 3rd ed., 1922), p. 54.

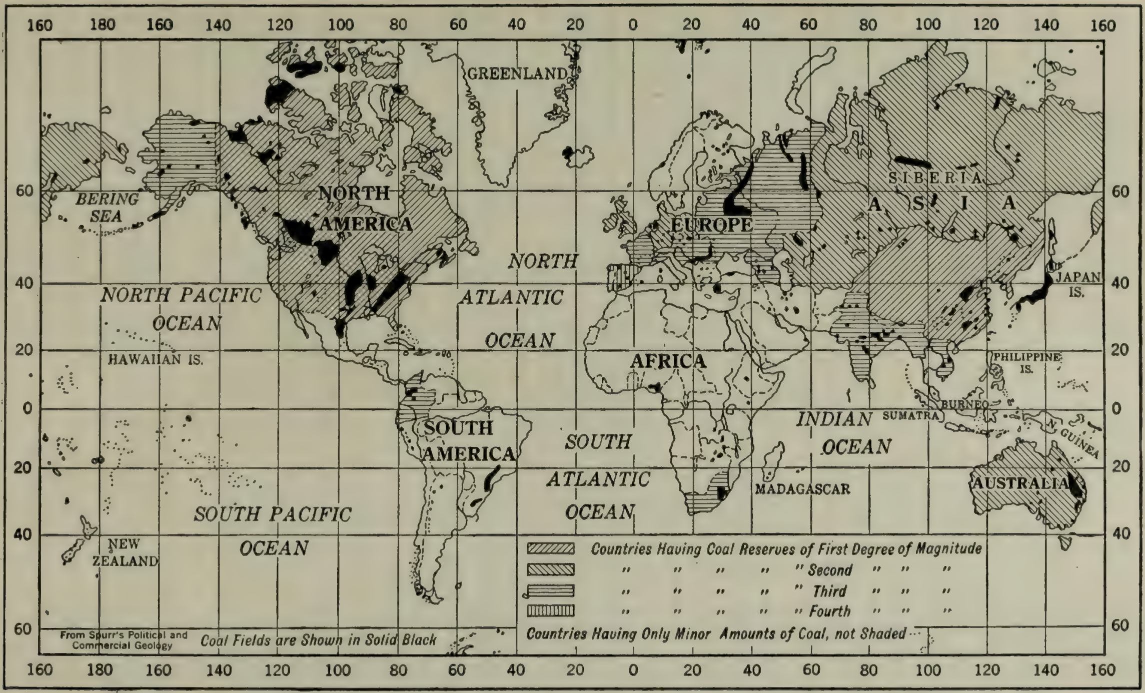
Sub-bituminous coal is black lignite with sometimes a fairly bright luster. It breaks parallel to the bed rather than with a columnar fracture as in the case of real bituminous coal. This coal disintegrates easily, and both it and lignite are difficult to store because of the danger of spontaneous combustion.

Bituminous coal has greater density than lignite or sub-bituminous, is black and more brittle, and breaks with a cubical fracture. All three varieties thus far described make a great deal of smoke in burning, while all grades above this are practically smokeless. It contains about 65 per cent gaseous matter, which makes it particularly desirable in manufacturing illuminating gas. Most coal mined is of this variety.

Semi-bituminous is a soft coal which breaks easily into slack, and it has a tendency to cake and crust in the fire. Its heating value is the greatest of any coal mined, and it is therefore desirable on ships which have a limited storage capacity. It has long been the standard for naval use. It contains about 80 per cent carbon and 15 per cent volatile matter.

Anthracite coal exists in different grades, but they are all hard, brittle, black and with a high luster, and showing a cubical fracture. It is desirable for domestic uses, as it is clean, smokeless, easy to handle, burns with a steady flame, and does not clog in a grate. The anthracite of eastern Pennsylvania is the best coal in the world, containing about 90 per cent carbon and below 5 per cent of volatile matter.

The coal fields of the world. — *North America.* — Coal is found in all but 14 states of the United States and the beds underlie 16 per cent of the total area of the country. There are five important fields: (1) the anthracite field of eastern Pennsylvania; (2) the Appalachian bituminous field extending from Pennsylvania to Alabama; (3) the eastern interior field of southern Illinois and Indiana, and western Kentucky; (4) the central interior field extending from central Iowa to southern Texas; and (5) the Rocky Mountain field reaching from northern New Mexico into Canada. Small deposits of good coal are found along the Pacific coast but they have only local use. As one goes westward, the quality of coal becomes poorer. The Appalachian and eastern interior fields produce bituminous coal of good quality and the central interior field some bituminous coal of fair quality; but the western coals in general are poor, much of the reserve being lignite. This prohibits their



Geographical Distribution of the Coal Deposits of the World, and Relative Reserves.
(By F. F. Grout)

extensive use at present, because their low heat value makes impracticable long railroad hauls to distant markets.

Canada has coal fields which are widely scattered and some of which are near the industrial centers. Deposits are found in three regions: (1) Nova Scotia and New Brunswick; (2) the Rocky Mountain margin of Alberta and of British Columbia; and (3) Vancouver Island. Three-fourths of the reserve is lignite.

Europe. — There are four important coal fields in Europe, including Great Britain. These are: (1) Great Britain; (2) northern Europe extending from the Valenciennes basin in northeastern France to the Ruhr basin of Germany; (3) Middle Europe at the junction of Poland, Germany, and Czecho-Slovakia; and (4) the Donetz basin of Russia. Scattered deposits are found in central France, and large unworked reserves in Spain, in the Balkans, and in Russia. With the exception of the coal of the Middle European field, most is of good quality, the Ruhr basin, Belgium, Central France, and Russia all producing some coal of coking quality. Operations in parts of the northern field, which constitutes the most important coal field in Europe, are expensive because of the folding of the strata. In the Donetz basin are found large reserves in from 25 to 40 workable seams, but they have not been worked much as yet.

Great Britain is favored in quantity, quality and wide distribution. There are five different coal areas, one in Scotland with Glasgow as a center, a second in Northumberland near Newcastle, a third in the vicinity of Leeds and Sheffield, a fourth in Lancashire near Manchester, and the last in South Wales. The deposits are also near iron deposits and most of them near the sea coast. Coal means much in the industrial life of Great Britain, for her foreign commerce is based upon coal. The greater part of British imports are bulky raw materials, while the majority of exports other than coal are manufactured goods which have a large value in a small bulk. If coal were not exported, many ships would be compelled to leave British ports partially empty, thus causing high rates on the products which are imported.

Asia. — Asia has large reserves of coal, but they have not been worked to any extent. The chief producer is Japan, which has coal in fair abundance and quality scattered widely throughout the archipelago.

Large quantities of high grade bituminous coal are found in all of the 18 provinces of China, and west of Pekin there is the largest reserve of anthracite in the world, extending over an area 18,000 miles square. Japan has developed some Chinese deposits because they are more easily mined than her own.

In India, especially in Bengal, coal is produced, some of coking quality; but most of it is so soft and pliable that it is not suited to all uses.

Australasia. — In Australia and the East Indian islands coal of average quality occurs in several places. The East Indian islands produce about 1,000,000 tons annually. In Australia production is centered near the sea coast of New South Wales close to Newcastle and Sydney. The coal is of medium quality and is used by Pacific steamers.

Africa. — In general the countries of the southern hemisphere possess but little coal. In Africa most of the coal is found in the Transvaal, with some in Natal. This coal is of fair quality, that of Natal being used as bunkering coal.

South America. — South America possesses the least coal of any of the continents and produces only one-fifth as much as Africa. About 80 per cent of the production comes from a small field in Chile, and the remainder from small deposits in Peru, Colombia, Venezuela, and southern Brazil. The largest reserve is in Colombia.

Coal production and reserves. — Although the coal resources of the world are distributed fairly widely, the actual production is highly localized. Over three-quarters of all the coal mined is raised in the three leading industrial districts, namely the United States, Great Britain, and Northern Europe. The two latter districts are exploiting their reserves so rapidly that they will be faced with serious problems if the present rate of consumption continues. Fortunately for the future of the human race the great reserves of China and of Canada and Newfoundland are almost untouched as yet. The following table shows approximately the percentage of total world production of the leading coal-producing countries for the pre-war period 1909–13 and for a post-war year 1924, together with the estimated reserves of bituminous and of all coal.

The average yearly production for the five-year period, 1909–1913, was 1,210,019,391 metric tons, and for the year 1924 it was

World Production and Reserves of Coal

COUNTRY	Average per cent of total world's production for the five-year period 1909–1913	Per cent of total world production 1924	Per cent of world reserves of bituminous coal	Per cent of world reserves of all coal
United States	39.5	38.5	50.0	51.0
United Kingdom	22.5	21.0	4.5	2.5
Germany	19.9	18.0	6.4	3.5
France	3.3	3.3	0.3	0.4
Rest of Europe	8.1	9.8	6.1	3.3
China	1.1	1.5	16.0	13.0
Rest of Asia	2.5	3.8	3.7	3.4
Australia	0.9	1.5	3.4	2.0
South Africa	0.6	0.8	1.1	——
Canada and Newfoundland	1.1	0.9	7.3	16.0
All other countries	0.5	0.9	1.2	4.9
Total	100.0	100.0	100.0	100.0

1,350,000,000 metric tons. The total reserves are estimated to amount to 7,258,966,000,000 tons. Of this amount 60 per cent is easily available and the remaining 40 per cent is accessible with difficulty. Bituminous makes up 53 per cent, lignite 40 per cent, and anthracite 7 per cent of these reserves.

Importance and uses of petroleum. — With the discovery of new uses petroleum has become increasingly important in modern industry, and to-day in certain lines is all but indispensable.

The first great use historically was for illuminating oil. Although to-day in our cities gas and electricity have displaced the kerosene lamp, this latter is the best and most economical method of lighting isolated houses which are not connected with a gas or electric supply. It was a great advance over lighting by candles, and even yet probably furnishes artificial light to a larger proportion of the world's population than any other illuminant.

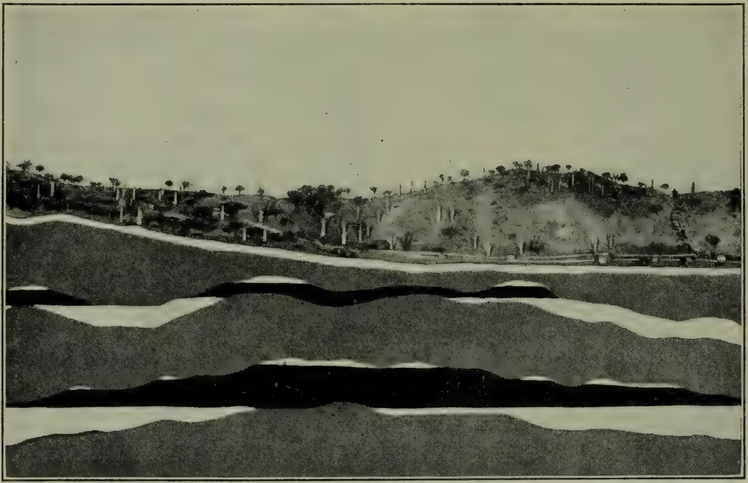
A still more essential use of petroleum is for lubrication. One of the great problems of early manufacturers was that of lubricating the bearings of their machinery, and for this purpose whale oil, tallow, and vegetable oils were used. But petroleum yields a lubricant far surpassing all others, and one that is indispensable in modern machine industry. At least one-half pint of lubricating oil is used for every ton of coal converted into power, and probably as much again in the machinery moved by this power and in such things as sewing machines, clocks, watches, and similar articles.

Important as these are, the third use of petroleum has attracted most attention; this is as a source of power. Petroleum may be used to generate steam and develop power by being burned instead of coal as ordinary boiler fuel. It has been used in this way especially on steamships, where the oil tanks take up less space than coal bunkers and considerable labor can be saved, as the oil flows by gravity and can be controlled by pipes and valves. To the ordinary citizen, however, petroleum yields power in the form of gasoline exploded in an internal combustion engine. In this form it is extremely efficient, a gallon of petroleum developing about fifteen horse power hours. The development of the automobile, the tractor, the airplane, and many other industrial machines has been rendered possible only by the invention of the internal combustion engine and the use of gasoline.

The fourth use of petroleum is the manufacture of various by-products, such as chemicals and dyes, solvents, paraffin wax, asphalt, and numerous other products. (See Chapter XXXIV).

The mere enumeration of these uses testifies to the importance of petroleum in modern industrial life. And yet there is danger of over-estimating this importance because it is kept so constantly before the public mind. Less than nine per cent of all the power developed in the world to-day is derived from petroleum, and if the entire petroleum supply were to be cut off completely it would only be necessary to increase the production of coal some eight per cent to develop the lost power. Burnable fuel for use in the internal combustion engines could be obtained from alcohol, and the various by-products could be recovered by the distillation of rock shales. The most serious loss would be the cheap and excellent lubricating oil now derived from petroleum, though that too could be obtained from shales, albeit at greater cost.

The formation of petroleum. — Petroleum is composed of about 84 per cent carbon and 12 per cent hydrogen with various amounts of sulphur, oxygen, and nitrogen. It is believed to be the remains of plant and animal life trapped by sediments and mud in ancient salt seas, which during the ages have been slowly changed and distilled by bacterial and geological action, chief of which is pressure due to the continued accumulation of sediments. The distilled product is forced upward then by gas and water pressure until, unless certain conditions prevent, it will escape into the air. The preventive conditions necessary to the accumulation of a reserve of petroleum in the ground are: (1) a porous rock which forms a reservoir for holding it, and (2) an impervious cover to this reservoir which prevents the escape of the oil. Oil is generally found in a dome-shaped rock structure. Pressure forces it toward the top of the dome and if the covering is impervious, there is no means by which it can escape. Petroleum is generally found associated with gas, water, and sometimes salt; the gas being on top, the petroleum next, and the water on the bottom unless there is salt. Where salt is associated it is the lowest product.



View of the Occurrence of Oil and Gas in Pools

The heavy black strips represent oil. The white pockets above the oil represent gas. The white below the oil represent water. The gray represents rock.

Oil bearing strata may be of any thickness up to 200 feet, and often, as in the Baku field of Russia, there are several strata at different depths. The porosity of the oil sand may vary from 5 to 50 per cent. In sandstone the average is between 5 and 15 per cent. Generally not over one-half of the oil is taken from the reservoir. The other half remains in the pores of the rock because there is not enough pressure to force it out.

Sometimes when a well is bored the oil rushes out with great force. This sort of a well is called a gusher and the pressure may be due either to gas or to water. In the Mexican field, where gushers are common, the pressure is due to the force of underground water.

Classes of petroleum. — Petroleums are divided into two major classes, those with a paraffin base and those with an asphaltic base. The oils having a paraffin base are more valuable because they are lighter and contain more gasoline and more lubricating oil than those with an asphaltic base. The latter are used largely for fuel purposes. Oils also differ in color, weight, and viscosity, some being light and very mobile while others are black and may require heating before they will flow through a pipe line. The nature of the oil is important in considering reserves because quality is important as well as quantity. The oils of the Mid-Continent and Eastern field of the United States, and those of Ontario, the Dutch East Indies, Burma, Persia, and Mesopotamia are of a paraffin base. The remaining reserves are chiefly of the heavier, low grade oils.

In the United States there is a similarity in the location of high grade petroleum and of high quality coal. In going from east to west the quality of both products decreases. Pennsylvania anthracite coal and Pennsylvania petroleum are alike in their high quality.

Petroleum production and reserves. — Oil is fairly evenly divided between the eastern and the western hemispheres, but the northern hemisphere has three times as much as the southern. One should remember, however, that the land area of the northern hemisphere is three times that of the southern, and also that much of the latter is unexplored. The greatest oil reserves are found in two widely separated regions, each containing about thirty per cent of the future supply of oil. The first of these regions is the area bordering on the Caribbean Sea, and the other is in western Asia and southeastern Europe with the Caucasus as an axis.

The following table shows the present and past production and estimated reserves of the principal petroleum-producing countries:

PRODUCTION AND RESERVES OF PETROLEUM[4]

COUNTRY	Per cent of total world production 1924	Per cent of total production 1857–1918	Per cent of total estimated oil reserves
United States and Alaska	70.5	61.42	16.26
Mexico	13.8	3.80	10.51
Russia (southeastern Russia, southwestern Siberia, region of the Caucasus, northern Russia, and Saghalien)	4.5	24.96	15.69
Roumania, Galicia, and western Europe	1.9	4.07	2.64
Persia and Mesopotamia	3.2	0.19	13.52
Northern South America, including Peru, Trinidad, and Venezuela	2.0	0.43	13.31
Southern South America, including Bolivia and Argentina	0.5	0.06	8.24
Other countries	3.6	5.07	19.83
Total	100.0	100.00	100.00

The total production for 1924 was 1,012,927,000 barrels, and for the period 1857–1918 it was 7,504,107,000 barrels.

Natural gas. — Natural gas is the most perfect, the cheapest, and the most convenient fuel known. Its desirability is due to the ease of obtaining and handling it, and to the absence of contained impurities which would have a bad effect upon products in whose manufacture natural gas is used as a fuel. These are chiefly glass works and iron and steel mills. It is found associated with coal and oil, and also in regions where neither of those products exists. Its geological formation is similar to that of petroleum.

In the production of natural gas, the United States leads with about 95 per cent of the world production. The industry in the United States in 1924 had a production of about 1,141,482,000,000 cubic feet valued at about $253,800,000, an amount equal to the value of the anthracite coal output. Canada follows the United States with about 3 per cent of world production, and the Dutch

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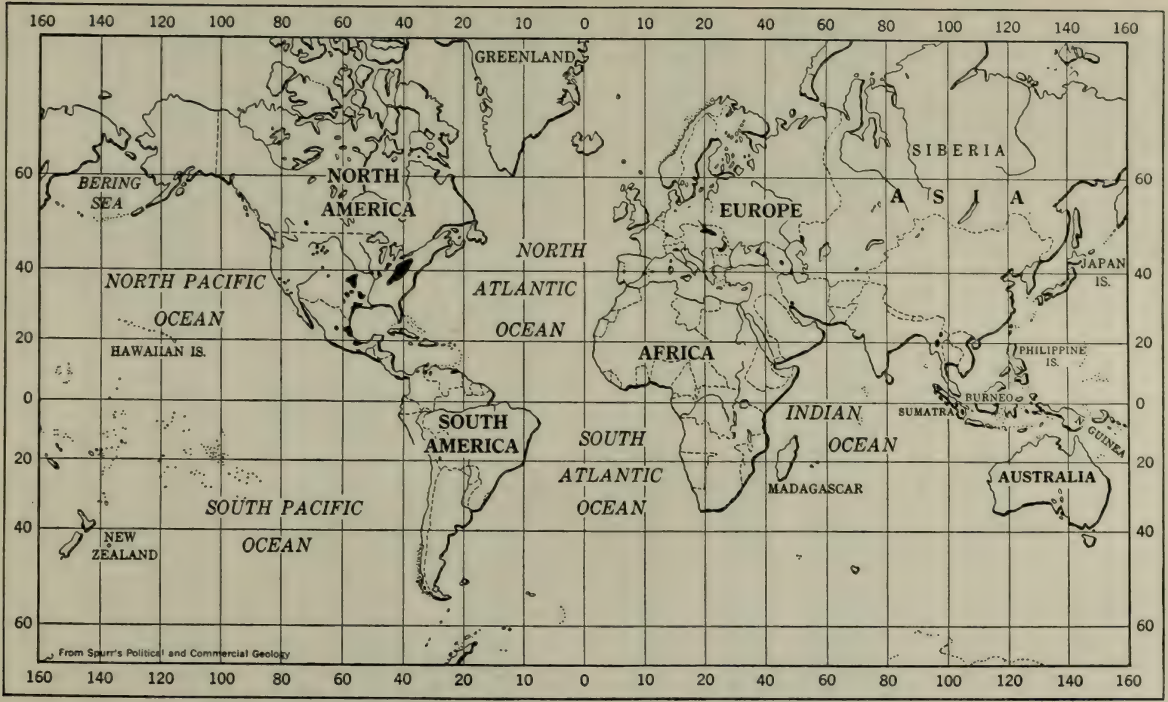
[4] Compiled from tables in *U. S. Geological Survey;* David White, "The Petroleum Resources of the World" in *Annals American Academy of Social and Political Science,* Vol. 89 (1920), pp. 123, 126; and *The Mineral Industry,* 1924.



From Spurr's Political and Commercial Geology

Geographical Distribution of the Producing Petroleum Fields of the World.
(By John D. Northrop)

East Indies, Mexico, Hungary, Japan, Italy, and England with an output of less than 1 per cent of total world production.

The natural gas fields of the United States cover an area of about 10,000 square miles scattered in some twenty states. It is of principal commercial importance in the upper Ohio valley and in Oklahoma. Of total production West Virginia contributes about 40 per cent, Pennsylvania and Oklahoma each about 17 per cent, and Ohio, California, Louisiana, Kansas, Texas and other states less than 10 per cent each.

Natural gas is used both for lighting and as fuel, about one-quarter of the output being used for generating power. Besides its use in the glass and steel industries, it is used in cement plants, brickyards, and many kinds of metallurgy. It is also used in making carbon black, about thirty per cent of the West Virginia output being employed in this manner. Helium gas, which is used as a non-inflammable substitute for hydrogen gas in inflating balloons, is also extracted from it. Another industry of growing importance is the extraction of gasoline from natural gas.

SUGGESTIVE QUESTIONS

1. How did the North American Indians, who did not know the use of coal, survive the rigors of winter?
2. Is peat a satisfactory fuel? Why or why not?
3. Find out the grades of coal best adapted to its different uses.
4. Locate the important coal fields of the world on an outline map; of the United States on a map of that country.
5. Explain the importance of coal in the foreign trade of Great Britain. What will happen when her coal resources are exhausted?
6. Find out the relative amounts of power contained in a ton of coal and a ton of petroleum.
7. Comment on the significance of the statistics presented in the table on page 192.
8. Explain the keen competition among the different nations for the control of the world's unused supplies of petroleum.
9. What different theories have been advanced to explain the origin of petroleum?
10. Locate the chief petroleum fields of the world on an outline map.
11. If all the petroleum wells were exhausted, would rock shale yield sufficient supplies?
12. What is the origin of the gas used in dwelling houses?
13. What is "coal oil"?
14. Comment on the significance of the statistics presented in the table on page 196.

BIBLIOGRAPHICAL NOTE

Since both this and the following chapter refer to mineral resources, this bibliography is intended to be used in connection with both chapters.

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CHAPTER XVI

MINERALS AS RAW MATERIALS

Classification of minerals used as raw materials. — The classification of minerals (p. 185) based upon use grouped them into the two classes of (1) mineral fuels and (2) minerals used as raw materials for other industries. This second class may now be subdivided into five groups.

Most important of all are (1) iron ore and the ores from which are derived the alloys used in making steel. The ferro-alloy metals are indispensable in transforming iron into steel, and especially in the manufacture of hard or tough steels. They include manganese, chromium, nickel, tungsten, vanadium, antimony, molybdenum, uranium, and zirconium, and a few other substances.

(2) The second great group is that of the ores of the major metals other than iron and the ferro-alloy metals; this includes copper, lead, zinc, tin, and aluminum. On the basis of use there may also be included here the ores of those metals used for abrasives, refractories, etc., such as emery and corundum, magnesite, graphite, mica, and asbestos.

(3) From an industrial standpoint the so-called noble metals must be placed after the baser metals. This group includes gold, silver, paladium, platinum, mercury, etc.

(4) The fertilizer minerals are essential for agriculture, and include phosphate rock, potash, nitrates, and sulphur.

(5) The last group contains the structural minerals, of which building stone and clay are the most important.

It will not be possible, within the limits of a chapter, to do more than indicate briefly the industrial uses of these minerals and the principal regions of their occurrence and production. But even this summary will serve to show the extent to which modern industry is based upon mineral resources.

Uses and importance of iron ore. — Of all the minerals iron ore is the most important and the most indispensable; it ranks next to coal as a factor in modern civilization. A country which possesses these two minerals, and has at the same time an energetic and capable people with initiative sufficient to utilize them, is sure to take its place among the leading powers of the world.

The uses of iron ore are so manifold that it is scarcely possible to enumerate them. From iron ore are manufactured cast iron, wrought iron, and steel, and these in turn constitute the raw material from which are made the thousand and one products which surround us at every turn. The equipment of factory, railroad, and farm, the huge office buildings and the appliances of our homes, our automobiles, watches, and pens — these and many others depend upon iron. But besides being used as a metal, iron enters into the manufacture of paints, chemicals of various kinds, coloring matter in glass and pottery, and even into jewelry. Considerable amounts of iron ore are also used every year for flux in smelting silver, copper, lead, and other metalliferous ores.

" Iron and its products," write Harder and Eddingfield,[1] " are more widely used than any other metal; and the yearly production of pig iron makes up 94 to 96 per cent of the total amount of all metals produced in the world, and in normal times averages about 80,000,000 tons annually."

Formation of iron ore. — Iron ore is formed by the processes of sedimentation, by igneous action, and by weathering, and is classified geologically as sedimentary, igneous, and residual. But since over 90 per cent of the iron produced to-day is obtained from sedimentary deposits, it will be sufficient to describe only the geological process by which these ores were formed.

In the formation of sedimentary ores, the metal was first dissolved from the crust of the earth, which contains about 4½ per cent iron, and carried in solution by streams of water. When a stream of water carrying iron in solution entered one carrying lime in solution, the iron was deposited. There are three types of sedimentary ores. The first type is represented by those ores which remained unaltered after they were once deposited. Most of the ores of the Appalachian region are of this type. The second type is those which, after having once been deposited, were further changed and concentrated by the action of surface water leaching out their impurities, chiefly silica, leaving the ore in a purer state than originally. The ores of the Lake region of the United States are of this nature. The Bilboa ores of northern Spain represent the third type. In this type surface water dissolved the iron from the surrounding rocks of the region and deposited it as a replacement of limestone subsequent to sedimentation.

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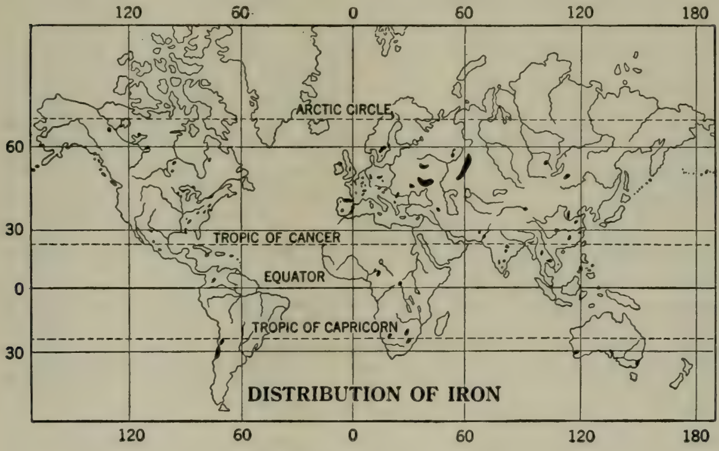
[1] E. C. Harder and F. T. Eddingfield, " Iron," in *Political and Commercial Geology and the World's Mineral Resources,* by J. E. Spurr (Ed.) N. Y. 1920. p. 55.

Composition of iron ore. — Upon the composition of an iron ore depends the possibility of its industrial use, and this is therefore a factor of great importance. The percentage of iron contained in the ore is of course primary, but in this respect there is a wide variation. Thus hematite contains about 70 per cent of pure iron, and pyrite only about 47 per cent, so that the former is more valuable from this standpoint. But the presence of other substances, such as phosphorus, sulphur, and titanium, which have a tendency to make the iron product brittle; or of excessive quantities of silica, lime, or magnesia, which make the ore undesirable for smelting; or of excessive moisture, which makes smelting too expensive — any of these factors may render an ore, rich in iron, less desirable than a poorer ore.

The cheapest method of making steel is by the Bessemer process, but this requires an iron ore with scarcely any phosphorus (less than .05 per cent), so that ores are usually divided into the two commercial groups of low-phosphorous Bessemer ores and non-Bessemer ores. Most of the ores in the United States have a higher phosphorous content, and are therefore smelted by another process known as the basic open hearth process; two-thirds of the steel made in the United States is produced by this method.

Since there is such diversity in the qualities of the ores it is customary to sample the ores as they are mined, and then to mix and load the ore in such a way that the desired grade will be obtained. Whatever may be true of pigs, it is not true that iron ore is just iron ore. On the contrary it is composed of a complex mixture of chemical substances which must be carefully ascertained before the ore can be used. Composition is of great importance in determining the availability of a given ore for any use.

Distribution of iron ores. — Iron ores are distributed plentifully throughout the world, but are mined and smelted on a large scale only in a comparatively few places where production is cheap on account of a fortunate combination of high percentage of iron, large deposits, proximity to coal, cheap transportation to markets, and large demand. These conditions are best met in the countries bordering on the North Atlantic Ocean, and in these countries consequently is concentrated over 90 per cent of the iron ore production of the world. The production of iron ore was as follows in the leading countries in 1913: United States, 61,980,437 gross tons or about 40 per cent of the world production; Germany, including Luxemberg, 35,941,285 gross tons or 20 per cent; France, 19,160,407 tons or 12 per cent; and Great Britain, 15,997,328 tons or 10 per cent. Spain, Russia, and Sweden produce about 5 per cent each. In addition to the countries named, Newfoundland and Cuba have very large deposits, but these have not been much developed as yet.



Distribution of Iron Ore

The United States has four regions in which iron ore is produced, the Lake region, the Appalachian region, the Birmingham district, and the Rocky Mountain region. At present the Lake region produces about 85 per cent of the ore of the United States and the Appalachian and Birmingham districts each 4 per cent. There is not much development in the West yet, due to restricted markets and the absence of coal.

The Lake Superior region, and especially the Mesabi range in northeastern Minnesota, is the greatest iron ore field in the world. This region produces one-third of the world production of iron ore annually, and the Mesabi range alone produces one-fourth of the total world production. The ore is abundant in quantity; it is cheaply mined, as it lies so near the surface that it is simply dug out with steam shovels and loaded onto cars; and it is easily transported to market by steamers on the Great Lakes. It is, moreover, unusually pure. The Lake Superior deposits, and the Spanish, Swedish, and Russian ores, contain from 50 to 65 per cent of metallic iron, while the Alabama deposits and the main British, French, and German supplies contain only about 35 per cent or less.

The following table shows the approximate percentage of world production of iron for the important countries for a pre-war year and a post-war year, and the percentage of the total estimated reserves which each country possesses to-day: [2]

COUNTRY	Per cent of world production for 1913	Per cent of world production for 1924	Per cent of total reserve of world
United States	36.0	39.0	31.0
Newfoundland	a	a	18.0
Cuba	a	a	11.0
United Kingdom	9.0	8.0	3.4
France	12.0	20.0	19.0
Germany	16.0	3.0	2.7
Sweden	4.0	5.0	4.7
Russia	5.0	0.7 [b]	2.1
Spain	6.0	3.0	3.7
Rest of world	12.0	21.3	4.4
Total	100.0	100.0	100.0

[a] Included under "Rest of world." [b] For nine months.

Ferro-alloy metals. — Iron and steel are valuable because they have, or may be given, certain qualities not possessed by other metals. These qualities are hardness, toughness, elasticity, durability, brittleness, density, porosity, endurance, resistance to oxidation or corrosion, malleability, fusibility, and magnetism. It is possible to control these qualities and give them in any desired degree to cast iron or steel by adding or subtracting other elements in the process of manufacture. The principal iron alloys are silicon, carbon, manganese, chromium, nickel, vanadium, sulphur, and phosphorus. Although they are present in very small quantities, generally less than 1 per cent and seldom more than 5 per cent, they are indispensable as accessories in the manufacture of iron. For instance, only fourteen pounds of manganese are needed in the manufacture of a ton of steel, yet steel cannot be made without manganese.

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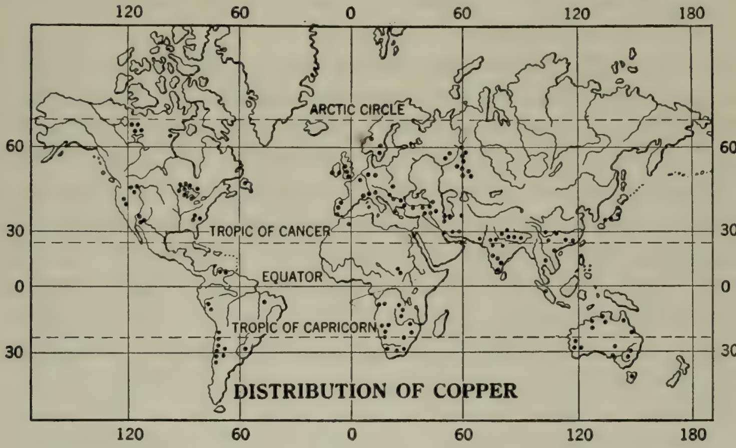
[2] Compiled from official sources.

These minor yet essential elements are often called "key" minerals. Curiously enough the geographical distribution of these iron alloys does not correspond at all with the distribution of the iron ores. The United States, extraordinarily rich in iron, has insufficient supplies of almost all the alloy metals excepting molybdenum and silicon. Most of the manganese is found in Russia, India, and Brazil; chromium comes from South Africa, Russia, and Turkey; nickel from Canada; vanadium from Peru; and the others from still different regions. The necessity of insuring themselves adequate supplies of these minor but essential alloys has led the larger European iron manufacturing nations to establish or attempt to establish control over the regions where they occur, and has led sometimes to serious international complications.



Distribution of Copper Ore

The major metals other than iron. — The second great group of metals other than iron, which are used as raw materials for manufacturing, consists of copper, lead, zinc, tin, and aluminum. Of this group copper is by far the most important, ranking second only to iron in industrial value. It has its widest use in the electrical industry, in which it is indispensable as it is the best cheap conductor of electricity known to-day. It is also used in manufacturing arms, in roofing, plumbing, and for ship bottoms, and to a small extent for money. Combined with zinc it forms brass, and combined with tin it makes bronze, and in these forms it finds many other industrial uses.

The chief uses of lead are in the manufacture of alloys, such as type metal, shot, solder, and casting metal, for mixing with paints, for lead pipe, as cable sheath for telephone wires, as containers of acids, and in lead compounds for various chemical and medical purposes. Lead ranks next to iron in volume produced, and as it is the cheapest metal after iron it is used where possible as a substitute for the more expensive metals.

Zinc is used chiefly for galvanizing iron and steel to protect them from rust, and to alloy with copper to make brass; it is also used in the form of rolled sheets for roofing and plumbing, and enters into the manufacture of pigments, electrodes, and other articles.

The principal use of tin is in the manufacture of tin plate, from which are made tin cans. Since modern methods of packing meats, vegetables, and fruits would be impossible without these containers, tin must be given a high rank among the metals. It is also used as an alloy with copper in making bronze, and with lead to make solder and babbitt; minor amounts are used to make tin foil, collapsible tubes for artists' colors, dental and toilet creams, and other purposes.

The chief uses of mercury or quicksilver are the manufacture of drugs and chemicals, and as a fulminate for high explosives. It is also employed in electrical apparatus, in the manufacture of instruments, for silvering mirrors, and for other minor industrial purposes.

Aluminum is daily finding new uses, but the principal ones at present are in the manufacture of parts of internal-combustion engines, and the making of industrial and household utensils.

Occurrence and distribution. — The ores of copper, zinc, tin, and most of the minor metals, as well as gold and silver, occur in localized deposits of varying form, depth, and geologic relations. Sometimes they are found in a pure state, but more often two or more of them are associated in the same ore. There are no wide areas underlaid with strata with well defined characteristics, and for this reason it is difficult to predict what discoveries may be made of any of these metals. After the deposits are laid down, the movements of the earth's crust may completely change their location and relation to each other, and may break veins into parts and separate by long distances the two ends of the fracture. Because of these facts it is practically impossible to estimate with accuracy the reserves of these metals.

As a producer of copper the United States stands preëminent over half (50.3 per cent) of the world output in 1922 coming from this single source; Chile ranked second with 14.9 per cent. These two countries with South Africa, are estimated to contain 83.2 per cent of the world reserves of this metal. In the United States the chief fields are in Arizona, Montana, Utah, and Northern Michigan.

The important lead producing countries are the United States, Mexico, Australia, Spain, and Germany. In the United States, the chief producing regions are in Missouri, Idaho, and Utah.

Zinc comes from about twenty-five different countries, but most of the production is concentrated in the United States, Australia, Germany, Sardinia, and Spain.

Tin is less widely distributed, and most of it comes from the Malay States, Bolivia, the Dutch East Indies, and China.

Bauxite, the chief ore of aluminum, is produced almost exclusively in the United States, although widely distributed.

It seems clear, from even this hasty glance, that the United States occupies an enviable position as a producer of the major metals, with the single exception of tin. Its industrial position rests upon a firm basis.

The noble metals. — Since the earliest times gold and silver have been prized because of their malleability, ductility, durability, and beauty, and have been used both as money and in the industrial arts. Perhaps two-thirds of the gold produced has found a use as money, and the other third has been utilized in dentistry, for jewelry, gilding, and other ornamental purposes. In the case of silver this proportion is exactly reversed. Most of the silver going into the arts is used for the production of jewelry and tableware, with a much smaller consumption for photographic and chemical work. The largest deposits of quicksilver ore occur in Spain and on the western coast of North America from Alaska to Mexico. Platinum is consumed entirely in the industrial arts, the essential uses being in the chemical and electrical industries and also dentistry. Pure platinum is required in the chemical industry for the manufacture of sulphuric and nitric acid, and for utensils in chemical laboratories, as crucibles, dishes, tongs, and the like.

Although none of these metals is as essential to modern industry as coal and iron, yet for the purposes to which they are applied they are vital. For use as money nothing else has ever been discovered that could equal them, and since money is the very heart of modern commerce these metals may well be given the name of "precious."

Occurrence and distribution of the precious metals. — Gold deposits are of two classes — placers, and veins or lodes. Placers are sediments which have been weathered and washed from veins and deposited in the channels of streams. A similar process takes place with platinum, tin, iron, copper, lead, and zinc, but none of them except gold and platinum has a sufficiently high value to warrant its recovery from placers. Most of the gold and practically all the silver are found associated with other metals, over half of the silver produced being obtained as a by-product in the mining of other metals, as lead, zinc, and copper. Platinum, like gold, occurs chiefly as the native metal, and 99 per cent has been derived from placers.

The world's chief gold producers are South Africa, Australia, and the United States. Three-quarters of the silver comes from Mexico and the United States. In the case of platinum Russia has always been almost the sole producer, but since 1914 its production has declined greatly, while Colombia has increased its output.

The fertilizer minerals. — These include phosphate rock, potash, nitrates, and pyrite and sulphur, and are valuable chiefly as ingredients in artificial or commercial fertilizers. There are some ten chemical elements which are essential to plant life, but three of these elements are of especial importance, namely, phosphorus, potash, and nitrogen. If these are lacking in the soils, crops will not thrive and agriculture becomes unprofitable. Sometimes they are present in insufficient quantities because of the character of the soil, but more frequently they are lacking because constant cropping has exhausted the supply originally present. If increased production of food is to be obtained, in order to feed the expanding population of the world, it is essential that these lacking elements be replaced in the soil in the proper quantities.

Phosphate rock is used mainly for artificial fertilizers, and to a smaller extent for making phosphoric acid and phosphorus. Potash is used almost entirely as an ingredient of fertilizers, though some is used, like phosphorus, in making matches, and the remainder for glass, soap, and pharmaceutical and metallurgical products. Nitrates also find their chief application in fertilizers, but are used to a small extent in the manufacture of explosives and of ammonia. Pyrite and sulphur are used interchangeably in the manufacture of sulphuric acid, from which is obtained acid phosphate for fertilizers. But the numerous other uses of these two minerals outweigh their value for this purpose; they are essential materials in the manufacture of explosives, the refining of petroleum, and a vast number of chemical industries.

Occurrence and distribution of the fertilizer minerals. — Phosphate rock is a sedimentary deposit containing phosphate of lime. About one-half of the world's output of phosphate rock is mined in the United States, which also has the lion's share of the reserves. In the United States three-fourths of the supply has come from Florida, although enormous untouched reserves over twenty times as large await future development in Montana, Idaho, Utah, and Wyoming.

Potash is a term commonly used to designate any of the salts of the element potassium. This is widely distributed as a component of rocks, soils, and vegetable and animal substances, as in the brine of salt lakes, in seaweed, etc., but large accumulations of potassium salts in forms suitable for man's uses have been found in only a few places. Of these the most important are the enormous deposits in northern Germany, which before the World War had a virtual monopoly of this product and now shares it with France.

Nitrogen is a free gas and is present in unlimited quantities in the atmosphere, but natural forces are constantly at work to fix this atmospheric nitrogen in the soil through the growth and decomposition of plants, and to build up nitrate deposits. Unfortunately, however, these nitrate minerals are in the nature of soluble salts, and there is therefore a constant tendency for rains and streams to leach them out and carry them to the ocean, where they contribute to its salinity, but are thenceforth lost for any useful human purpose. Under exceptional conditions, where the drainage has been into a landlocked basin with no escape except through evaporation, the salts have accumulated and caused a deposit. Such a condition seems to have occurred on a large scale only once, in Chile, though future discoveries may some day unearth other deposits. Other sources of nitrates are from guano, slaughter house refuse, fish scrap, cotton seed cake and meal, etc.; as a by-product from coke ovens and blast furnace operations; and through the fixation of atmospheric nitrogen by electric power.

Structural minerals. — The last group of minerals of economic importance to be considered comprises the building stones and clays. The principal building stones are granite, limestone, marble, slate, and sandstone, although not all rocks of these kinds are useful for building. The strength of the rock, its color, ease of splitting and dressing, durability, and nearness to market all help to determine the availability of a given deposit. These stones are used for the construction of buildings and bridges, as ballast for railroads, in paving and curbing sidewalks, for roofing, as refractory material, for cement, concrete, monuments, and for a variety of minor uses. They are so generally distributed throughout the world that each country and locality is generally able to meet its needs from local supplies. In the case of the finer grades of marble, granite, and limestone, however, the stones will bear the costs of distant transportation.

Clays are used principally for building and paving brick and tile, road material, Portland cement, pottery, terra cotta ware, sanitary ware, and similar purposes. Clays have a wider distribution than most economic minerals and are found generally distributed throughout the world. Deposits of high grade clays exist in England, France, Belgium, Germany, and Czecho-Slovakia, from which high-grade china and pottery are made. The United States possesses large deposits of a coarser character, the best being in Ohio, Pennsylvania, New Jersey, and Illinois, and in these states the leading clay products industries are situated.

Conclusions as to minerals. — Of the 1500 known mineral substances, some 200 are used in modern industry; of these less than 50 are of prime importance, and only half this number have been thought of sufficient moment to warrant description in the preceding chapters. The world's annual output of mineral resources is estimated by Leith[3] at 2,000,000,000 tons, divided as follows: coal nearly 70 per cent, stone and clay 10 per cent, iron ore about 9 per cent, petroleum 4 per cent, copper ore 3 per cent, and all the remaining minerals together less than 6 per cent. It thus ap-

[3] P. 60.

pears that half a dozen minerals contribute 95 per cent of the total production.

The geographical concentration of mineral production is equally striking. Three-quarters of the annual production comes from three countries, the United States furnishing 39 per cent, England 18 per cent, and Germany 18 per cent. Most of the remainder comes from other European countries. These figures do not mean that nature has concentrated the mineral wealth of the world in the region around the North Atlantic Ocean, but rather that in those countries live people with energy, ability and knowledge sufficient to enable them to utilize these resources. Great unmined deposits exist in other parts of the world, which may be developed in the future as other countries adopt the processes of modern industry.

Of great political as well as economic significance is the fact that the mineral resources of the world are so unevenly distributed that no country has within its boundaries all the minerals needed in modern industry. The United States is better off than any other country, but is deficient in a few very important ones, such as tin, manganese, nickel, platinum, potash, and some minor metals. In the possession of minerals which enter into modern industry most largely, however, the United States is singularly fortunate. It leads the world in the production of coal, iron, petroleum, copper, zinc, silver, sulphur, phosphate rock, molybdenum, uranium, radium, and aluminum. Next to the United States stands the British Empire. Together, these two countries practically control the world's mineral industries, though other individual countries have a partial monopoly on certain particular resources, as platinum in Russia, nitrates in Chile, potash in Germany and France, mercury in Spain, nickel in Canada, and a few others.

One final observation may be made, which is fraught with serious possibilities. The production and utilization of mineral resources on the present scale is of very recent date. Writing in 1921, Leith stated that more coal has been mined in the United States since 1905 than in all the preceding history of the country; more iron since 1906 and more oil since 1908. Gold production on a large scale dates from 1849, diamond extraction from 1869, aluminum from 1889, and in the case of fertilizer minerals, the ferro alloys, and other metals consumption in large quantities is of even later date. Although the utilization of the mineral wealth has been the latest conquest of modern industry, it seems as though man were determined to make up for lost time by lavish and rapid exploitation. What the consequences of this policy may be for future generations must be left to the future to determine.

Conclusions as to geographic factors. — It is evident from even this brief survey of geographic factors that these tend to condition man's activities and to set limits to industrial development. Their importance is largely negative, however, and they are only slightly under man's control. They provide the framework merely; man himself contributes the positive influences which modify his environment and lift him above it.

Geographic conditions determine and condition man's activities most in the earlier stages of industrial progress. Then man seeks a location providing purely natural advantages of climate, resources, and position. Later, when he is able to distribute raw materials and fuels by steamship and railroad, he emancipates himself somewhat from the dominance of physical factors. He learns, moreover, to modify his environment by heating his buildings, by constructing harbors, by fertilizing or irrigating the land, and in other ways. Other factors begin to play a more important part in determining man's progress. His own mental growth and the development of social forces contribute more largely, and the technical improvements which constitute modern industry and which result from these other factors become almost dominant.

SUGGESTIVE QUESTIONS

1. Define the term ore.
2. Locate on an outline map the chief regions of occurrence of the minerals named in this chapter.
3. Compare the location of the iron ore and the coal deposits within the major manufacturing areas. Are there any unused reserves similarly situated?
4. What is the economic importance of alloy minerals?
5. Which of the minerals mentioned in this chapter do you consider most essential? Why?
6. Is the term "precious" properly applied, on economic grounds, to gold and silver?
7. Explain the large deposits of fertilizer minerals in Chile and on the islands off the coast of Peru. How is the United States situated with respect to fertilizer minerals?

8. List all of the products that you can, into the making of which any one of the different minerals mentioned in this chapter enters.

9. Should any peculiar economic significance be attached to the location of the chief reserves of iron ore?

10. Find out the political significance of the Briery iron ore fields.

11. Do political boundaries and economic boundaries ever conflict with each other? If so, give examples. What is an economic boundary?

12. Is there any economic boundary between the United States and Canada? Between the United States and Mexico?

13. Why is the manufacture of cement scattered so widely throughout the United States?

14. In Europe the majority of dwellings are built of stone; in the United States of wood. Account for the difference.

BIBLIOGRAPHICAL NOTE

See references to preceding chapter.

PART IV

THE EXTRACTIVE AND GENETIC INDUSTRIES

CHAPTER XVII

CLASSIFICATION OF INDUSTRIES

A classification of industries. — The effort to gratify human wants, either material or non-material, is the basis of all the economic activities of mankind. It is true that some persons make a living by uneconomical or non-productive methods, as by thieving or gambling or cheating, but such persons merely divert to themselves a portion of the wealth or income produced by other people without rendering a just return. All persons engaged, as the United States Census puts it, " in gainful occupations " may be thought of as occupied in producing goods or services which gratify wants, and therefore as engaged in productive labor.

The classification of industries in our modern economy may be illustrated by the following chart:[1]

MODERN INDUSTRIES AND SERVICES
- Primary industries
  - Extractive
    - Hunting
    - Fishing
    - Grazing
    - Lumbering
    - Mining
  - Genetic
    - Agriculture
      - Tillage
      - Plant breeding
      - Animal breeding
    - Forestry
    - Fish culture
- Secondary industries
  - Manufacturing and constructive
    - Weaving
    - Steel making
    - Engineering
    - Building
    - Road making
  - Commercial
    - Transportation and communication
    - Merchandising
    - Warehousing
    - Banking
    - Insurance
  - Personal and professional services
    - Healing
    - Teaching
    - Protecting
    - Inspiring
    - Governing
    - Amusing, etc.

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[1] Combined from two tables in T. N. Carver, *Principles of Political Economy*, p. 192; and *Principles of Rural Economics*, p. 20.

Such a classification as the above aids in two respects. In the first place it gives us a broad view of the entire field of industry. Classification shows to each individual his place in the industrial machine and his relation to other individuals and groups of individuals. In the second place, a better idea of what is going on in the business world is obtained, if like industries are grouped together and compared with other groups of like industries. Each group of similar industries has important functions to perform, as does each worker within any one group; and by classifying them upon some such basis as the above, these functions may be more easily grasped and the relation of one group to another and the interdependence of groups better understood.

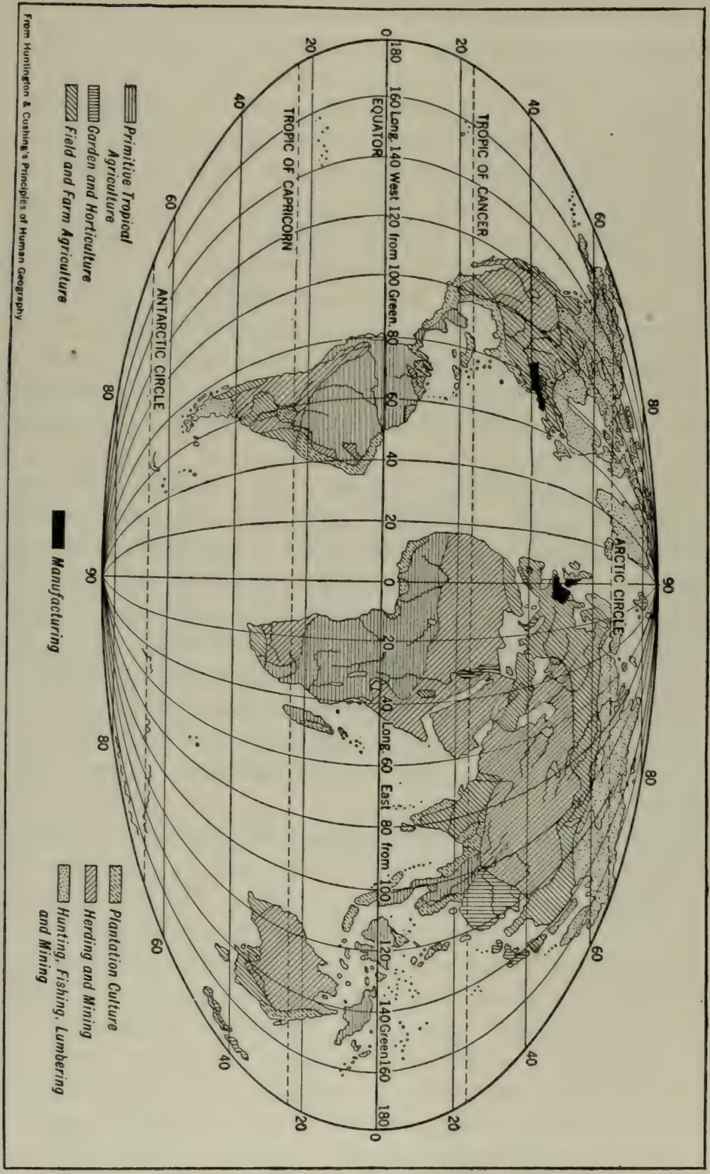
The meaning of production. — A distinction has sometimes been made between those engaged in the extractive, genetic, and manufacturing industries on the one hand and those engaged in commerce or professional and personal services, on the ground that the former group produced tangible, durable goods, and the latter rendered only temporary services. So, too, the agriculturalist has sometimes been deemed more productive than the manufacturer because, it was said, nature coöperated more generously with the farmer and he therefore brought into existence new wealth, while the manufacturer only changed the form or combination of existing matter.

Such distinctions are not tenable. All persons engaged in gratifying human wants, that is in producing economic goods or services for which other persons are willing to pay, must be regarded as engaged in productive work. In no case does man create; that is an attribute of Deity. All that man does is to rearrange particles of matter in such a manner that the forces of nature can operate upon them so as to produce an article useful to man. The farmer who plants his seed, the manufacturer who grinds the wheat into flour, the railroad which transports it to the city, the baker who converts it into bread, and the grocer who finally delivers this to the consumer, are all engaged in one continuous productive process. The sum total of these productive activities may be grouped together under the term " industry," the subject to which the remainder of this book is devoted. Its purpose is not merely to describe the actual productive processes in the various industries, but also to emphasize the debt which industry owes to science.

The primary industries. — The primary industries are concerned with obtaining from the environment raw materials which may be used directly by man, or, as is generally the case, which supply the manufacturing industries with materials to be worked up into consumable goods. The primary industries may be divided into two groups, according to whether or not they replace the materials taken from the earth and water. If they do not replace or restore the elements withdrawn and used up they are extractive industries; they definitely diminish the store of raw materials. If, however, they replace the materials used with others they may be called genetic or growing industries. As usually conducted, hunting, fishing, grazing, lumbering, and mining are purely extractive or exploitative; and much of our agriculture has been of the same character. When properly carried on, however, every one of them except mining could be brought into the genetic group, as witness the fox farms in Canada, scientific forestry in Germany, fish culture in our inland streams, and improved farming.

Hunting and trapping. — Historically, hunting was the earliest method by which man gained his livelihood. At first he simply appropriated the products which nature spontaneously provided, in the form of fruits, nuts, berries, and similar kinds of plant life, and in those kinds of animal life which were easily obtained, such as slugs, worms, birds, eggs, etc. Later he became powerful enough to kill game and use its flesh for food and skins for clothing; and after the discovery of fire he added fish to his dietary. To-day hunting and trapping are relatively unimportant activities, practiced only in undeveloped regions and usually for the sake of skins and furs.

Mining. — By mining is meant the extraction of minerals and metals from the earth. The term is generally expanded so as to include all of the operations about a mine, but in its strictest sense it includes only the extraction of ores. The industry is usually localized and almost always found in rough or mountainous regions. It is less under the control of man than any other industry, for the very existence of mineral resources is determined solely by nature without any reference to human needs, and their location is hidden from him by being buried beneath the surface of the earth. The industry is purely extractive, for there is no way by which man can replenish the mineral stores which he takes from the earth.


Primitive Tropical Agriculture
Garden and Horticulture
Field and Farm Agriculture
Manufacturing
Plantation Culture
Herding and Mining
Hunting, Fishing, Lumbering and Mining
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
ARCTIC CIRCLE
180 160 Long. 140 West 120 from 100 Green. 80 60 40 20 0 20 40 Long. 60 East 80 from 100 120 140 Green 160 180
0
20
40
60
80
90

From Huntington & Cushing's Principles of Human Geography

MODES OF LIFE. (Adapted from Bartholomew)

Agriculture. — Of the two main branches of agriculture — the rearing of herds and the cultivation of the soil — the former is historically the older. The domestication of animals came long before the taming of wild plants and the raising of crops. During the pastoral stage man subsisted upon the yield of his flocks and herds, living a nomadic life and moving from place to place in order to obtain good pasturage for his cattle. He lived in tents and clothed himself in skins, but his roving life prevented the development of industry. As thus carried on grazing was a purely extractive industry, since the pasturage was provided spontaneously by nature and no effort was made to maintain or improve it. Grazing on the ranges of our western plains has been carried on in the same way. Animal breeding as it is now conducted in the Mississippi Valley, where the feed is artificially raised and the animals are frequently stall-fed, has become a genetic industry.

The other branch of agriculture — that of plant breeding and tillage of the soil — developed later than the domestication of animals. When man reached this stage of development he forsook his nomadic ways and settled down to a sedentary life. Instead of tents he began to build substantial dwellings, and in time to practice the industrial arts. Agriculture has thus great historical importance, as marking the real beginning of modern industrial life; it has also great practical importance because it provides the foodstuffs without which man cannot live. For this reason it has often been regarded as the fundamental industry of our economic system.

Forestation. — The lumbering industry exploits the resources of the forests and converts them into commercial products for man's uses. As generally conducted it is a purely extractive industry. Forestation means the planting and care of forests so that there may be a future supply of timber to replace that cut down; thus conducted, it becomes a genetic industry as truly as agriculture. It differs from agriculture, however, in the length of time necessary to harvest a crop; most agricultural crops mature within a year, while a forest crop will ordinarily require half a century. Because of this fact and the large amount of capital that is tied up, forestry is best conducted on a large scale by the state or by corporations with perpetual life, while agriculture yields the best results on small farms under private ownership.

Aquaculture. — Aquaculture includes all of those forms of activity which take from the water, or cultivate under the water, products which are of commercial importance. Under this term therefore, would be included fishing; the cultivation of fish, oysters, and sponges; the extraction of potash from seaweed; and the securing of such products as gold and salt from the water. Practically everything that can be obtained from the air or the earth can be obtained in some form from water, and with the increase in the world's population, along with the exhaustion of natural resources, aquaculture because of its slight development is likely to be of increasing importance.

Conservation and the primary industries. — As practiced in the United States and in every new country where natural resources are plentiful and labor is scarce, the primary industries have all been extractive in the true sense of the word. We have until recently extracted without placing anything back upon which to rely in the future. The soil has been butchered and exhausted; the forests cut down without being replaced; and practically no attention at all has been paid to the commercial possibilities existing in the water. But increasing population and increasing costs of living are forcing people now to give some attention to conservation of natural resources. Mining is an extractive industry in the true sense of the word and that is all it ever can be, because man can do nothing to produce a new supply of minerals when the old ones are exhausted. He must await the completion of geological processes which require centuries. But man can conserve the soil by using scientific methods in agriculture; he can maintain a supply of forest products by planting new trees when mature ones have been harvested; and he can use and increase the supply of products in the water by giving attention to the growing of fish and to the utilization of other marine products.

In a new country, conservation is not profitable. The people are placed amidst new surroundings and must secure a living in the most economical manner. In this country in colonial days, natural resources were plentiful and labor and capital were scarce; so the inhabitants used the cheaper and conserved the more expensive things. But the result was bad, because our natural resources were exhausted and because wasteful habits regarding the exploitation of resources were developed in the people, from which we have not yet recovered. Now that our supply of cheap land has become practically exhausted, as have also our forests, methods of working these must be changed and more attention devoted to conservation. We are just beginning to make a little progress in this respect.

The importance of the extractive industries. — The importance and scope of the extractive industries may be seen from the following table, which shows the percentage of the total tonnage of the different classes of products which were carried by the railroads of the United States for the three year period 1920–1922.[2]

CLASS OF COMMODITY	*Per cent of total amount carried*
Products of agriculture	10.62
Animals and their products	2.42
Products of mines	54.39
Products of forests	8.30
Manufactures and miscellaneous	19.94

According to this table the products of the extractive industries form approximately four-fifths of the amount of all products carried by the railroads. It would be misleading, however, to conclude that these figures represented the relative importance of the different products. Based as they are upon quantities rather than values, the heavy, bulky articles loom larger, while the small but valuable manufactured articles make up only a fraction of the whole.

The next table gives the approximate values for the annual world production of the chief products of the primary industries at present price levels. These figures are only estimates, because it is an impossibility to get reliable and full data for every commodity and every country in the world, but they are based upon reliable sources.[3]

I. Products of agriculture	
A. Cereals	
Rice	$8,000,000,000
Wheat	5,000,000,000
Corn	3,500,000,000
Others	6,000,000,000
Total	$22,500,000,000

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[2] Averages based on figures taken from the Annual Reports of the Interstate Commerce Commission.

[3] Based upon table in Huntington & Williams — *Business Geography,* 1st ed., pp. 14–15.

B. Animals and their products	
Dairy products	$5,000,000,000
Sheep, goats, and wool	4,500,000,000
Cattle and hides	4,000,000,000
Swine	2,500,000,000
Poultry and eggs	2,500,000,000
Horses, asses, and mules	1,500,000,000
Total	$20,000,000,000
C. Fruits	$950,000,000
D. Vegetables	
Potatoes	$5,000,000,000
Beans	1,500,000,000
Others	300,000,000
Total	$6,800,000,000
E. Fibers	
Cotton and by-products	$2,300,000,000
Flax	550,000,000
Others	300,000,000
Total	$3,150,000,000
F. Miscellaneous	
Hay	$3,500,000,000
Sugar	2,000,000,000
Coffee	600,000,000
Tea	300,000,000
Tobacco	400,000,000
Rubber	400,000,000
Total	$7,200,000,000
Total for agriculture	$60,600,000,000
II. Products of mines	
A. Non-metallic	
Coal	$6,000,000,000
Petroleum	1,500,000,000
Total	$7,500,000,000
B. Metallic	
Iron	$2,000,000,000
Copper	500,000,000
Gold	400,000,000
Others	540,000,000
Total	$3,440,000,000
Total for mines	$10,940,000,000

III. Products of forests	$2,000,000,000
IV. Products of fisheries	$670,000,000
V. Value added by manufacturing	$15,000,000,000
Grand total	$89,210,000,000

Importance of the genetic industries. — The genetic industries may properly be called primary because in the first place they furnish the food which is essential to life. In addition to the food supply they also provide many of the raw materials of manufacture and articles for trade. Moreover, with the exhaustion of natural supplies not only of minerals but also of lumber, we shall be compelled more and more to grow the products which we need. Thus if we use up our metals we shall have to grow more wood to take their place; if petroleum is exhausted we shall have to produce more industrial alcohol from wood or corn or potatoes; if the forests themselves give out we shall have to grow more grasses to manufacture into paper and other products to supply other uses. As the population of the world increases greater demands will be made upon the genetic industries, not only for food but also for industrial raw materials, like fibers, rubber, skins, and other similar products.

Historically, agriculture is the most important of the genetic industries, for it marked the change from a nomadic to a settled life in which alone civilization could develop. It has moreover maintained its importance, for to-day, in spite of the development of commerce and manufacturing, the majority of the world's population is engaged in agriculture in one form or another. In industrially developed countries, however, the relative importance of agriculture has declined within the past century, due on the one hand to the greater productivity of improved agricultural processes, and on the other to the development of new wants and other lines of production.

Agriculture in the United States still ranks as the largest single industry — if it can properly be called a single industry — and employs over one-fourth of the nation's workers. The primacy of agriculture in the United States is due to several causes: (1) the large area, variety, and high average fertility of the soil; (2) the favorable and wide range of climate, which permits the production of a wide variety of products; (3) the energy, ability, and progressiveness of the agricultural workers; (4) the excellent facilities for marketing products; (5) the use of improved labor-saving machinery; (6) the popular tenure of the land, and the simple laws for the registration of titles and the transfer of land; and (7) the activity of national and state agencies in introducing and encouraging the use of scientific methods.

The manufacturing and constructive industries. — The manufacturing industries proper may be classified into transforming or mechanical, chemical, and assembling manufactures.[4] In the first of these, of which weaving may be taken as an example, the raw material is transformed in shape and appearance by mechanical processes, but no essential change is wrought in the nature of the product. In chemical manufactures, however, of which steel making is typical, the raw material undergoes chemical changes which completely alter its character, so that the finished product is essentially different from the raw material. The assembling type of manufactures simply brings together partially or wholly finished units and combines them into a new whole; an illustration of this would be the manufacture of a locomotive or a watch or an automobile.

The constructive industries closely resemble the assembling type of manufacture, for they take as their raw materials the finished products of the manufacturing industries, and change their positions or combine them in ways to effect the desired result. Thus, in the construction of a bridge or an office building the workers bring together steel shapes, dressed stone, wooden beams or sash or doors, and cement, and combine them into the finished product.

To make an adequate classification of manufacturing industries would be difficult. The usual method is to divide them according to the kind of commodities produced, and such is the classification given by the Federal Census. Fourteen general groups are listed as follows:

Food and kindred products
Textiles and their products
Iron and steel and their products
Lumber and its manufactures
Leather and its finished products
Paper and printing

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[4] See Chapter XXX.

Liquors and beverages
Chemicals and allied products
Stone, clay, and glass products
Metals and metal products, other than iron and steel
Tobacco manufactures
Vehicles for land transportation
Railroad repair shops
Miscellaneous industries

Such a classification is clearly only a broad, general one. If each individual industry which is subsidiary to these larger ones were given, the list would occupy more pages than this general one contains lines. One illustration will suffice to show this. Under Iron and Steel and their Products are listed 33 different subordinate industries, and several of these contain in turn a number of subdivisions. Thus, the main branches are crude iron and steel and rolled products, while " other products " comprise cash registers and calculating machines, engines, firearms, foundry and machine-shop products, gas machines and gas and water meters, hardware, and other items down to wire. Under hardware, for instance, are listed locks, builders' hardware, piano and organ hardware, vehicle hardware, and all others. This sample is sufficient to show the comprehensive nature of manufacturing, and the large and important place which it occupies in the industrial world as a means of satisfying human wants. In the United States the value added by manufacturing processes to the value of the raw material in 1909, 1914, and 1919, was 41, 40, and 40 per cent respectively; so 40 per cent may be taken as an average figure for the contribution made by manufacturing to the value of the product.

The commercial industries. — The commercial industries constitute the organized system for the exchange of goods between the members of the industrial world, and may be considered as the last link in the chain of productive activities. The important types of services rendered by this group of industries are those of the transportation company, the merchant, the banker, and insurance companies.

The work of the transportation company is to deliver goods and messages. It takes the goods and communications that are entrusted to it and delivers them to those persons to whom they are consigned. The transportation company takes products from a place where they are not needed to one where they are needed. It equalizes supply and demand. It does not own the goods, but does own the means and facilities for transporting them.

The agencies which compose a country's transportation system are rivers, canals, lakes, water fronts for harbors and docks, highways, railroads both steam and electric, aviation companies, express companies, pipe lines, sleeping car companies, telegraph and telephone companies, the post office, and radio stations.

The service of the merchant is to discover the needs of consumers and to devote his time to the satisfaction of these needs. He buys goods from the producer and sells them to consumers at the time and place where they can be of greatest use. Thus one can see that the function of warehousing is united with that of merchandising. Goods cannot be sold as soon as acquired. One producer does not have enough to satisfy the desires of a large number of people. Neither does he know where the best market for his product is. So, the merchant or middleman enters at this point and buys up the products of many producers, assembles them, holds them, and distributes them as the demand for them arises.

The service rendered by banks in the marketing of products may not be so obvious as that rendered by merchants or transportation companies but it is fully as important. It requires the united effort of banks, merchants, and transportation companies to carry goods through all the stages until they are finally consumed. The service of the bank consists in collecting the small capitals of many depositors and placing them at the disposal of the people who are engaged in the production and the buying and selling of products. A manufacturer may want to buy a large stock of raw material but has not the necessary funds. He goes to his banker and obtains a loan. With the proceeds from this loan he can buy the raw material and continue the operation of his plant. A middleman could not operate without bank loans. He is continually buying up small lots of goods and storing them. He does not have the funds himself with which to do this. With the aid of his bank he can continue buying and storing goods. Thus the service of the banker is extended to all who are engaged in the production or merchandising of commodities.

The function of insurance is to distribute or spread the risks incidental to all forms of industry, such as those from fire, tornado, and similar destructive agencies. The insurance company collects small premiums from a large number of persons or businesses scattered over a wide area. If any one of these persons suffers damage the combined premiums are used, up to the amount of his insurance, to indemnify him for his loss. It is a coöperative or mutual protective association by means of which the many uninjured members come to the aid of the few injured ones in their moment of need. Insurance has great economic importance.

Importance of manufactures and commerce. — Although in the chart of modern industries manufactures and commerce were entitled " secondary industries," it was not meant to suggest that they are of minor importance. They are secondary only in the sense that other industries must first produce the raw materials which the manufacturer works up into finished goods and which the merchant distributes. Just as the extractive and genetic industries are essential to the manufacturing and commercial industries, so the latter are necessary in order to make available for human consumption the raw materials of the former. Thus the iron ore must be smelted and refined and made into finished articles, the wheat must be milled and baked, the cattle must be slaughtered and the meat dressed, the tree must be felled and sawed and converted into chairs and tables and similar things before they are ready for final use. And then these goods must be transported and distributed to the consumers. The various industries constitute a logical sequence in which each is dependent upon the others, and in which the dependence runs back as well as forward in the work of providing goods which will gratify human wants.

Some writers, like Friedrich List, have arranged the industries in a series in the order of their historical development, in which agriculture, emerging first, ranks lower than manufactures and commerce. Those nations which develop manufacturing industries and foreign commerce progress beyond those which confine themselves to extractive industries alone. But List, no less than the earlier writers who proclaimed the superiority of agriculture, failed to grasp the essential interdependence of all the industries. " Each for all and all for each " is as true of industry as it is of other activities.

Direct services. — Persons rendering services directly to the consumers, or those engaged in professional and domestic service, are not engaged in the production of material commodities but of immaterial satisfactions. These may be more important than the more tangible and permanent goods and may even be necessary for the latter's production. They are as truly productive in gratifying human wants as the labors of a farmer or of a manufacturer. A physician heals the sick and gives instruction as to the best means of keeping well. Teachers aid in the mental development of a people, making possible the keener enjoyment of life as well as more and better production by the individuals who come under their training. Judges, soldiers, policemen, and firemen protect the country and make life and property more secure. Ministers appeal to the higher motives and stimulate the development of a more spiritual and moral life. Legislators enact and administrative officials enforce laws necessary to keep our complicated industrial system in running order. And finally actors, musicians, lecturers, and other persons entertain and inspire us in our leisure moments. Direct services may make us more efficient producers; but their real justification lies in the fact that they first of all make us happier, more contented, and better.

Distribution of the workers among different industries. — There were in the United States in 1920, according to the Census of that year, almost 42,000,000 persons listed as employed in gainful occupations. These were distributed among the different types of industry which have been discussed as follows:

Distribution of Workers

INDUSTRY	Number at work	Per cent of total
Manufacturing and mechanical industries...	12,818,524	30.8
Agriculture, forestry, and animal husbandry.	10,953,158	26.3
Personal, domestic and professional services.	9,445,782	22.7
Trade	4,242,979	10.2
Transportation	3,063,582	7.4
Extraction of minerals	1,090,223	2.6
Total	41,614,248	100.0

From these figures it appears that almost a third of those gainfully employed are engaged in the manufacturing and mechanical industries; these embrace a vast number of varied employments, so that the number engaged in any one line is not so great as those engaged in the group of agricultural industries, which is about one-quarter of the total. Personal and professional services, another heterogeneous group, accounts for about a fifth, and trade for a tenth. Transportation, with over one-fourteenth, is also important; but mining, forestry, and fishing absorb but a small fraction of our national energy.

SUGGESTIVE QUESTIONS

1. Explain fully why an actor may be considered a producer.

2. What is the basis for the distinction between the extractive and the genetic industries?

3. Why is one group of industries designated as primary and another secondary?

4. Are there any peoples at present who are in the first stages of the agricultural industry?

5. What is the nature of the business of the regions that are dependent upon the different types of extractive industries? (See Huntington and Williams, *Business Geography,* revised edition, pages 325–343.)

6. Explain why the conservation of natural resources is not profitable in a new country. Should the nation be interested in any other type of conservation?

7. Find out the leading manufacturing industries in the United States according to the value of the output.

8. Transportation companies and merchants equalize demand and supply. Explain.

9. Can domestic servants and housewives be classed among the gainfully employed? Explain.

10. As time goes on and the country develops is it likely that agriculture will produce a larger or a smaller proportion of our national income?

11. Would you count it a sign of national decay, if an increasingly larger proportion of the population were engaged in personal and professional services as cooks, waiters, actors, musicians, policemen, lecturers, ministers and similar producers of immaterial utilities?

12. Is it possible to rank the industries of a country according to their merit? Construct such a list and submit it to class criticism.

13. " Only agriculture and mining are truly productive; for they only add to the sum total of wealth." Is this correct?

BIBLIOGRAPHICAL NOTE

Material on the classification of industries, as such, is scarce and fragmentary. That which does exist is largely covered in a chapter or so in different books and is very poorly organized. Material on the different industries can be found in the bibliographical notes of the chapters which discuss those industries in detail.

An excellent and very complete book on business organization is W. C.

Weidler, *An Introduction to Business* (New York, 1925). Another readable book is M. Keir, *Industrial Organization* (New York, 1923). A popular elementary treatment is given in R. E. F. Ridint, *The Industries of the World* (London, 1925). Books of an historical nature in this field are E. Cressy, *An Outline of Industrial History* (London, 1923), and Ellen L. Osgood, *A History of Industry* (New York, 1921). John A. Hobson, *The Industrial System* (London, 1919), *The Science of Wealth* (London, 1911), and *The Evolution* of *Modern Capitalism* (revised edition, London, 1906), also contain much valuable material. Books with one or a few chapters of this nature are H. C. Adams, *Description of Industry* (New York, 1917); J. Stephenson, *The Principles and Practices of Commerce* (London, 1918); T. N. Carver, *Principles of Political Economy* (Boston, 1919); and Huntington and Williams, *Business Geography* (New York, revised edition, 1926). Carver's discussion is probably the best of these. A. Marshall, *Industry and Trade* (London, 1919), contains much valuable but scattered material on the different industries.

CHAPTER XVIII

MINING

Nature of the mining industry. — The extraction of minerals from the earth is the only type of industry that is extractive in the full sense of the term. Agriculture, lumbering, and fishing are termed extractive industries but in those, the elements that are removed can be replaced. Minerals, however, can be replaced only by natural forces which may require tens of thousands of years for their complete operation.

The mining industry is divided into three general phases: (1) prospecting or exploration; (2) development; and (3) permanent mining.

Prospecting. — This phase consists of discovering and valuing, tentatively, new bodies of mineral deposits, whether it be iron, coal or raw products for making cement. There are various ways of accomplishing this. The old-time prospector, around whom centers a great deal of romance, wandered about studying the surface rocks and trying to find those that appeared to be ore. If his findings proved satisfactory he filed the necessary documents with the government, after marking his claim, and then proceeded to remove as much of the ore as he could.

But the modern prospector works differently. He is a geological expert. Instead of studying the surface rock he studies the geological structure of an area. He compiles all known data regarding the geological formations and their structures, undertakes systematic drilling, obtains fair samples and has them analyzed and evaluates the factors of market, transportation conditions, and cost of production. He may cover an entire mining property or a whole region in his investigation. In this manner, the value and profitableness of an entire ore deposit can be determined before actual mining operations are even started. Such work is placing the mining industry upon a more scientific and businesslike, and less risky, basis.

Development. — After it is determined whether the mineral deposit is rich enough and extensive enough to warrant the construction and equipment of a mining plant and mill, the next step is the careful study and preparation of plans for mining, milling, and transportation, and computing the cost and securing the necessary capital. Considerable capital is required for this work. The work on such a project may cease at any time either because the deposit of ore disappears or because of lack of market, cut in the market price, increased cost of operation, or increased cost of transportation.

With the more valuable minerals, where deposits may be small or may give out without warning because of the complex nature of the rocks, prospecting and development are very necessary; but in the baser mineral products as coal, iron, and granite, where deposits are large and thick, these two stages are of minor importance. A geological expert in some cases can determine at the beginning the quantity and quality of the ore, and the cost of extracting it or can formulate such a picture in his mind of the mode of recurrence and origin of the deposit as to give him assurance of satisfactory quantity and quality. The industry in a short time can be permanently established.

Permanent mining. — When a body of ore is sufficient in quality and quantity to justify the investment of a large amount of capital in expensive mills and machinery and other necessary facilities for handling, the mining industry usually settles down or becomes permanent. This is a relative term, for no deposit will last forever, but some will not become exhausted for so long a period that they may be considered as relatively permanent. Some of the copper mines of Spain and the tin mines of Wales have been worked for centuries, the coal beds of England have been worked for a hundred years, and the iron deposits of the Lake Superior district have been worked for forty years, but as yet they show no signs of exhaustion. Permanent mining is usually established in connection with coal, iron ore, and other coarse minerals, but with the more valuable ones it is not likely unless the company commands sufficient capital to buy and work a large body or several bodies of ore, because these metals usually occur in small veins which may suddenly give out. If the body of ore is small operations may have to be suspended, but when a large body or several bodies of ore are controlled, others may be worked when one gives out.

Large-scale ownership in mining. — Because of the uncertainty with respect to the life of many mineral deposits and the large amount of capital investment necessary for successful mining the industry to-day is tending to concentrate in the hands of large companies. In general, this is a benefit because, with large capital, the industry can adopt more scientific methods and plan better for the future. There is still risk, but it can be distributed more. Under a single ownership profitable mines can absorb the losses of poor ones. Large companies can also command expert advice and managerial ability which, in the first place, lessens the risk of starting mining operations, and, secondly, insures better success in the conduct of operations.

Large-scale ownership is also more economical. There is a smaller number of competitors and thus the competition in the extraction of the ore is not so keen as if a large number of small-scale producers were operating. This will result in a more economical use of the minerals. This situation is plainly evident in the case of petroleum. Large enterprises are economical again in that they have sufficient capital to employ the machinery and processes necessary for the extraction of low grade materials when the opportunity for this arises. The same is true in periods of falling prices when they are forced to obtain lower costs of production in order to maintain operations. Large-scale enterprises can also use any by-products of the industry to better advantage.

Factors which determine the profitableness of an ore deposit. — The factors which determine whether or not the working of a body of ore will be profitable are: (1) size of the deposit; (2) depth of the deposit underground; (3) quality of the ore; (4) association of other ores in smaller quantities with the main ore; (5) geological structure of the region and of the ore deposit; (6) quantity of ground water; (7) availability of fuel for smelting and refining, and (8) accessibility of the region to transportation facilities for bringing in supplies and sending out the mined product.

Location of the mining industry. — Minerals, and thus the mining industries, are commonly found in rough or mountainous regions with the exception of some deposits of coal and petroleum. Valuable minerals are apt to be found in such places because of the geological processes of the bending, breaking, uplifting, and subsequent erosion of the earth's crust which bring to the surface and cause to be exposed, large quantities of valuable minerals. Regions of gentle relief in some cases do contain minerals, as for example, Illinois, which ranks fifth among the states in the value of mineral products. Other prairie states are not so fortunate.

Rugged regions, valuable for little else at present except lumber in some instances, are important then as the centers of the world's mining industry. In the United States, the Rockies and the Appalachian range are both important as centers of the mining industry; the Appalachian range for the baser minerals and the Rockies for the more valuable ones.

Characteristics of mining communities. — The nature of the work in the mining industry creates an environment that is peculiar to the industry. The work is apt to be oppressive, dangerous, difficult, and often seasonal. Working underground also has a peculiar mental effect. Money is spent freely while it lasts. The camps and villages are unattractive and schools and churches are practically lacking. Drunkenness and gambling are common. Conditions are worse in the temporary communities than where the industry is permanent. Families with a settled abode are attracted to the latter type, but in the former type of community not many families are found. The inhabitants there are usually single men who shift from one place to another. But in either class of community living and social conditions are generally on a lower level than in any other type of industry, excepting possibly in the slums of some of our industrial cities.

Seasonal nature of mining. — A characteristic of many mining communities, especially in the coal fields of the United States, the iron ore fields of the Lakes region, and in all regions subject to a heavy snowfall and seasonal fluctuation of varying demand is the seasonal nature of the industry. Climatic conditions are, for the most part, responsible for this. People do not store their winter supply of coal during the summer months, but wait until cold weather arrives before they purchase it. The result is idleness on the part of the mines for a part of the time and then a heavy demand which necessitates the hiring of extra men. In some instances transportation is intermittent. The Lakes are closed to navigation because of ice for about one-fourth of the year. In the mountains, the canyons are filled with snow during the winter months so that transportation is next to impossible. Another cause of unsteady employment is the possible change in the demand for a particular mineral; since mining communities ordinarily produce one or a few articles only changes in market demands may have far-reaching effects on the welfare of the miners. In some cases, notably the coal mining industry in the United States, this seasonal nature of the industry and the resulting loss of wages during the idle part of the year, has led to demands for a shorter workday in order that employment and wages may be spread more evenly throughout the year.

Temporary nature of mining towns. — Because of the temporary nature of mining in many cases, towns have a boom and in a few years decline to a position of little importance as the ore becomes exhausted. Georgetown, Colorado, is an example of a town which has decreased from a population of 10,000 inhabitants at the height of its prosperity to less than 600. Virginia City, Nevada, the location of the Comstock Lode, the richest ore deposit in the world in proportion to its size, is another illustration. At one time a city of great prosperity, it declined in activity so that for a long period the streets were nearly empty and schools and business houses closed. There has been a revival lately because of the discovery of new ore and the consolidation of properties.

Transportation difficulties. — As agriculture in mountainous countries is nearly impossible, most mining communities so situated are entirely dependent upon the outside world for their supplies, and, as transportation is often difficult and costly, this is a great disadvantage. Mining towns in the mountains, where snow practically stops transportation during the winter months, must buy a stock of supplies which will last throughout the winter. In many of the towns in Colorado the supplies which do go in during the winter go by parcel post. Express companies and railroads will not try to handle the articles; and parcel post rates are 5 or 6 times as high as for packages going to more accessible locations.

The dangers of mining. — Mining at its best will always be a dangerous and disagreeable yet enticing occupation. The danger from gases is ever present in some coal mines. These may cause suffocation or an explosion which may kill the workers or cut off their means of escape. There is always the danger of chunks of mineral or rock falling from the walls or the roof, or the collapse of the roof in a small section. A miner's pick may strike a vein of water which will rush forth and flood the mine in a short time. A fire may break out and the workers be trapped in the mine. In coal mining, rock dusting is in vogue; that is the walls of the entries or rooms and also the floors and ceiling are coated with rock dust in order to prevent fire.

Neither is the occupation a healthy one. A mine is a dark, dusty, wet place, and such conditions lead to a variety of diseases of the skin, throat, and lungs. Also, miners are often required to work in a cramped or stooped position which is very tiring and not conducive to good health.

Methods of mining. — There are two methods of mining, underground and surface mining. In underground mining either a horizontal tunnel or a vertical shaft is dug through the earth to the mineral deposit, while in surface or open pit mining, the earth and other material covering the mineral deposit is removed, and the deposit of ore left exposed, is mined by the use of steam shovels.

The remainder of this chapter will be devoted to a discussion of these two methods of mining. The mining of coal will be used to illustrate the methods of underground mining, since most coal is mined in this way; and the mining of iron ore to illustrate surface mining, since the greater part of the iron ore of the United States is mined in this manner.

Prospecting for coal. — Coal is usually found deeply imbedded underground, and prospecting is necessary to determine the character of the formation, and the position, extent, number, depth, and kind of roof and floor of the seams before actual mining operations are begun. There are two methods of prospecting for coal — the trial-shaft and the boring methods. The former method is preferred when the thickness of the rock to be cut through is not great and its general character is known, and was formerly used more than now, but, as it is very expensive, it is not used unless the presence of coal is practically assured. The boring method is the one most frequently employed, and gives the best results in experimental work.

In general two methods are used in boring holes, one using percussive action with the churn drills and the other by diamond drilling. By the churn drill method heavy steel chisels or cutters of various styles are raised by derricks and permitted to fall or are driven against the rock, and a hole is gradually cut out. This hole will vary in size from 3 to 18 inches, and is generally lined with a pipe or tubing, as in the case of oil wells, water wells, and other borings. In the rotary system the hole is bored out by a rotating hollow steel crown, usually set with black diamonds — hence called a diamond drill — which cuts a solid core out of the rock. This core rises within the crown and is drawn out of the tubes, thus giving a sample of the strata through which the cutting is being made. As the core is drawn out the pieces are arranged in order and numbered, so as to give a record of the strata through which the shaft will pass.

Sinking the shaft. — The working of coal seams may be conducted either by means of horizontal tunnels driven through the outcrop on the side of a hill, or of vertical shafts sunk from the surface, or by stripping. As most coal fields are in fairly level regions the vertical shaft method is common. The first thing to do is to locate the shaft. It should be so placed as to serve the largest amount of coal bearing area at a minimum of expense. If the trial borings show that the coal seam is a level one, then the shaft would be best situated in the center, in order that the travel from the shaft to all other parts of the mine may be reduced to a minimum. If, however, the seam is inclined, then the shaft is best situated at the deepest portion, so that the coal will run down to it by gravity and the water will drain down.

The size of the shaft will depend upon the amount of coal mined each day, but the average size for the United States is about 16 x 16 feet. The depth, of course, depends upon the position of the coal seam, but the usual shaft is about 500 feet deep; the deepest shaft in an American coal mine is that at Assumption, Illinois, 997 feet. The form of the shaft may be circular, rectangular, etc. If the circular form is adopted, as is usual in England and Europe, the walls are lined with masonry — generally brick — though in some cases, where the shafts are sunk below sea level, cast iron linings are used. In the United States the shafts are generally square and are lined with wood, this being cheap and strong, though likely to decay. A shaft is frequently divided into four parts by partitions. In two of these compartments the hoisting cages operate; a third one is used for ventilation; and the fourth for water pipes, electric wires, and other necessary appliances. At least two shafts are required by legislation in most states, in order that the miners' chances of escape may not be cut off in case one of the shafts becomes closed to them. A second shaft also aids in providing better ventilation throughout the mine.

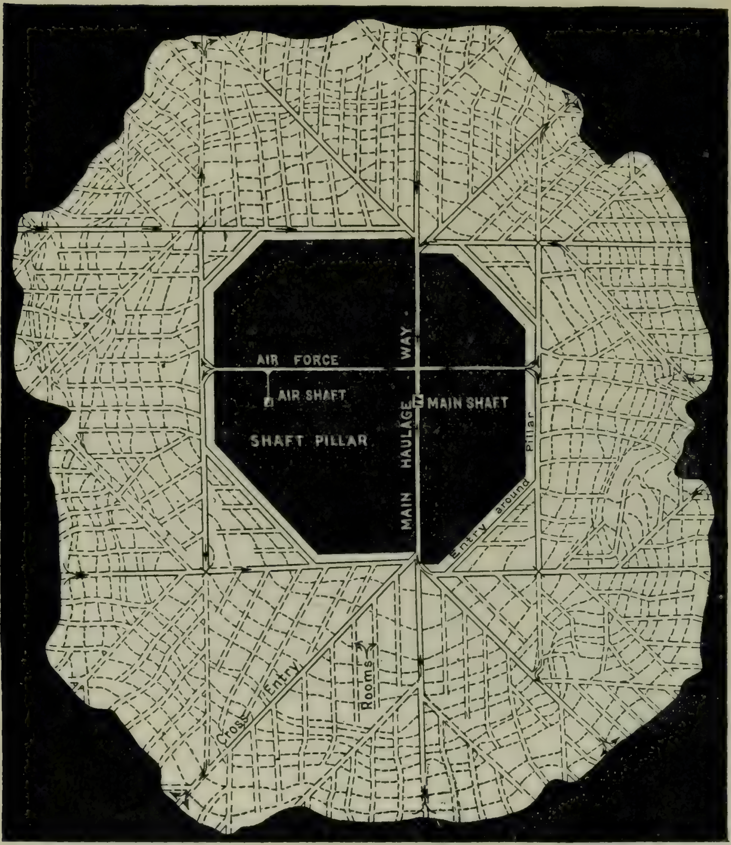
The layout of the mine. — From the bottom of the shaft galleries or " entries " are run in both directions along the seam, and these galleries are intersected at intervals by cross galleries, so that the pattern of the mine finally resembles the streets of a city.

This resemblance is heightened by the fact that along most of these streets run tracks on which the coal cars are propelled, that they are lighted by electricity, and sometimes they even have " traffic cops " to control the trains of coal cars at points of intersection. A regular railway system exists in some mines, as many as 600 miles of track being found in one Pennsylvania mine. Near the bottom of the shaft there usually is a room which houses the engines, pumps, boilers, ventilation furnaces, supplies, and lamps. A well-equipped machine shop is also provided, for the tools and machines need constant sharpening and repair.

Methods of working. — There are two main methods of working a coal mine, namely " long-wall " and " room-and-pillar."

By the long-wall system all the coal is extracted at one working, in one continuous line of face, none of the coal being left to support the roof. The roof is temporarily supported by wooden props for a sufficient breadth along the face to protect the workmen, and as the coal is removed pack-walls are built of stones and rubbish. After the coal is removed the wooden supports are pulled out and the roof is permitted to fall or subside on the pack-walls, only the main gallery being kept open and clear. This system is used especially in thin seams and where plenty of natural material is available for building pack-walls. In such mines it has several advantages: it yields a large output at once after the mine is opened; all the coal is extracted, and there is little waste; and the pressure of the unsupported roof makes it easier for the miner to get it out without the aid of explosives, and in larger pieces. This method is generally used in British and Belgian mines, where the seams are thin and the mines very deep, and also in parts of the United States.

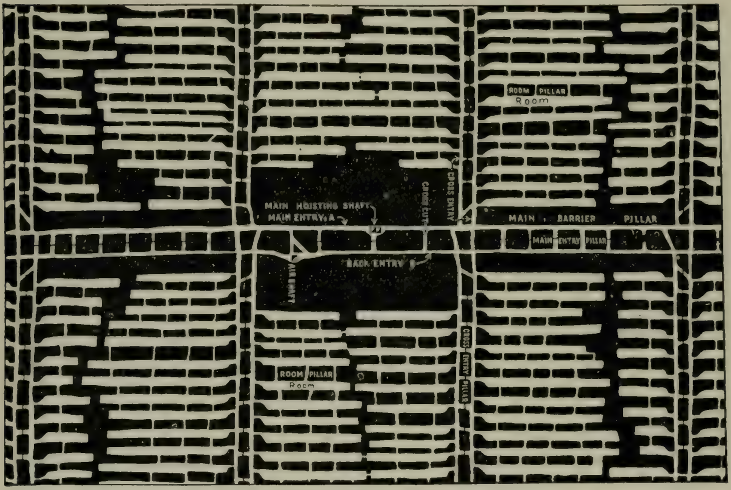
The room and pillar method is that usually employed in the United States. It is cheaper but more wasteful than the other. Under this system galleries are driven in every direction, leaving most of the coal in the form of pillars or ribs to support the roof. This is necessary where the mine is comparatively near the surface and where subsidence of valuable land must be guarded against. These pillars sometimes contain as much as 80 per cent of the coal, only 20 per cent being taken out at the first working when the entries are driven through. It must not be supposed, however, that only 20 per cent of the coal is mined. After the first working and after galleries have been driven on either side to the edge of the seam, then the work of removing the coal in the pillars begins. First a slice of coal is taken off the edge of a pillar, and then supporting timbers are erected to support the roof while another slice is cut off. The great economic problem in connection with this method of working a coal mine enters here: how far shall the



Long-wall System of Coal Mining

According to the long-wall system the entire bed of coal is removed as the work progresses, the roof at the face being supported by timber, gob, and pack-walls, and the necessary roadways being maintained by pack-walls. A pillar of coal is usually left surrounding the shaft for its protection from the subsidence of the surrounding strata. The work, once begun, progresses in a long continuous face. Part of the waste obtained in mining the coal is used to fill the space left by the removal of the coal. The remainder of the waste is hoisted out. In northern Illinois there is hoisted about one-third as much rock as coal.

ribs or pillars be robbed of coal? If too much is taken the roof caves in and there is a subsidence of the land above. If too little is removed, it is uneconomical. Much depends on the value of the surface land as compared with the value of the coal, or the existence of valuable structures, whether it be homes, bridges, or right-of-way. In Illinois, only about 50 per cent of the coal in the mine is actually extracted, the rest being left in the form of pillars to support the roof. It must not be thought that it is possible to hold up the weight of the superincumbent rock by any system of timbering. The main object of this is merely to protect the miners from falling pieces of loose roof rock and to hold the latter temporarily in place.



Plan of Room-and-Pillar Mine

In a typical room-and-pillar shaft coal mine in Illinois two parallel entries, one used for haulage (" A ") and one for carrying the ventilating current (" B "), are driven on each side of the shaft through the solid coal toward the property boundaries. The pillar of coal between these entries varies from 16 to 65 feet; they are connected at 60-foot intervals by cross-cuts for the purpose of maintaining a flow of air through the entries. About 300 feet from the shaft a pair of cross-entries is driven to the right and left of the main entries and at a right angle to them. The cross-entries vary in width from 8 to 20 feet, and the coal between them from 12 to 50 feet. Rooms are turned off at regular distances; these vary in width from 18 to 40 feet and in length from 250 to 300 feet. The coal remaining between rooms, called the room-pillar, is from 6 to 30 feet in width.

Loosening the coal from its bed. — The most difficult and expensive operation in the production of coal is, in general, the process of loosening it from its solid state. The process of loosening the coal from its native bed is accomplished in two ways: by blasting it from the solid face, as is done in most of the mines in the anthracite regions and in some bituminous mines; by undercutting and blasting, or letting the weight of the roof break the coal; this is done in most bituminous mines. Until the introduction of machinery the usual method of removing the coal was by manual labor, where the men used straight picks to loosen and tear down the layers of coal. This was very wasteful, slow, and expensive, but undercutting by hand labor was equally so. Undercutting or holing is making a horizontal cut into the seam to release the coal below or above, so that it finally falls down of its own weight or can be blasted down. To cut under the seam of coal was one of the most severe forms of human labor; the miner had to lie on his side and use the pick in a most constrained position. In order to have room in which to wield the pick it was necessary to cut out the coal to a considerable height, which was wasteful. To-day this work is largely done by machinery.

The introduction of power machinery for cutting and loading coal opened a new era in this industry. Coal-cutting machines were first made possible by the application of compressed air about 1870, and thirty years later their use was further stimulated by the introduction of electricity. The type of cutting machine most used in the United States has an endless chain as the cutting device. The chain exerts a tearing action which both cuts and clears out the débris. Such a machine first cuts straight into the face, about 5½ feet deep — "sumping in," as it is called — and then moves across the face of the coal. The coal is then shoveled out from the cut and carted off, and the bottom of the undercut seam is beveled off by the miners' picks, so that the block, when blasted off, will roll over and give the maximum amount of large lumps.

The use of power machinery in coal mining has some very striking advantages. In the first place it relieves the miner of the exhausting physical labor of undercutting, it gets out the coal in larger sizes and in a cleaner condition, and it sometimes, though not always, reduces the working cost. The miner who operates a machine gets higher wages than the old pick and shovel worker, and exercises higher powers of brain and muscle. Without machinery for cutting and handling, it is doubtful whether the demands of modern industry for coal could be met.

Blasting. — Explosives are used from time to time in order to loosen and break up the coal so that it can be worked more easily. The holes into which the explosives are inserted are made by pneumatic drills, which work ten times as fast as a miner with the old hand tools. The kinds of explosives permitted to be used in blasting are designated by legislation and are restricted to those kinds which, like dynamite, give a short cold flame and hence do not cause explosions. Black powder, which was formerly used, gives a long hot flame and is very dangerous in the gaseous atmosphere of a coal mine. For the same reason fuses are seldom used, but the blasts are set off by a detonator fired by electricity and operated from a central switch.

Hauling. — After the coal is loosened it must be taken to the shaft to be raised to the surface. The precise method used depends upon the inclination or dip of the seam, the quantity of coal extracted, and the methods of working. The broken coal is usually loaded into small cars running on rails and holding about two tons each. Tracks are run to the parts of the mine where the coal is being mined, and provision is made for switches, turn-outs, and often for double tracks. Where the galleries are fairly level, the cars may be drawn to the shaft mouth by small electric engines, and on steeper slopes a rope and revolving drum is used. The endless rope or chain system is probably the most important method of mechanical haulage in American coal mines; it operates like a cable or trolley, the cars being provided with clutches or grips by which they are attached to the rope. On steep gradients gravity systems are sometimes used, the full cars going down an incline and pulling the empty ones up.

Hoisting. — From the tracks the loaded cars are run directly into the hoisting cage which carries them to the surface. The hoisting devices are of great importance, for upon the amount of coal raised to the surface and the rate rather than the amount extracted in the workings will depend the output of the mine. Upon the successful operation of this part of the plant, moreover, depend the lives of the miners and other persons who descend into the mine. The cage consists of one or more platforms connected by an open framework of iron, to the top of which a cable is attached which passes over a great revolving drum. The cable is wound and unwound as the drum is revolved by an engine, and the cages are thus raised and lowered.

When the cars or skips reach the surface they are run from the hoisting cages to a platform, where the coal is dumped into chutes, after which it goes through one or two further processes before it is ready for the market.

Preparing the coal for market. — As the coal slides down the chutes after being dumped from the cars it goes between large steel rollers which break up the large lumps. Then it is carried to a series of screens with meshes of various sizes, which sort it according to size. These screens shake or jiggle with a drunken motion, so as to keep the coal in motion and carry it to the meshes through which it can fall to the bin intended for it. As the coal passes down the chute or over the screen boys pick out the impurities — pieces of stone or slate — and sometimes the coal is washed also in order to remove the sulphur, iron pyrites, and impurities that could not easily be removed by hand. Perhaps one-fifth of the bituminous coal mined is treated in this manner. The coal to be washed is carried over screens in a stream of water, and the heavier impurities sink while the coal is carried on. From the bins under the screens the coal is loaded into railway cars according to size, and is then ready to be carried to market.

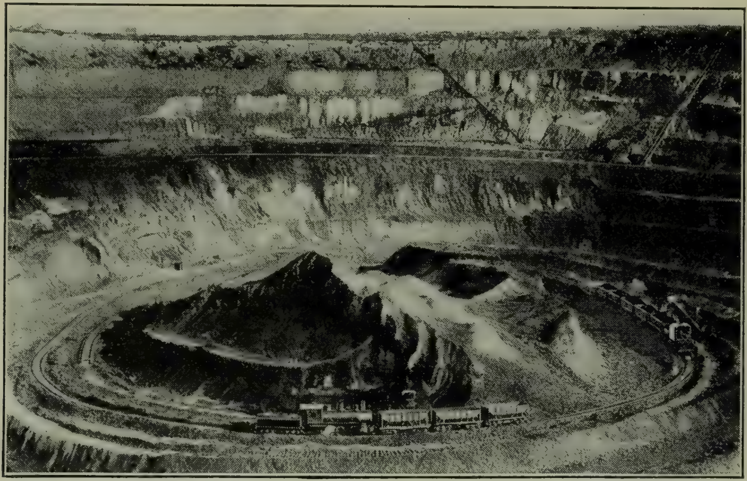
Mining iron ore. — As an illustration of open-pit or strip mining the method of extracting iron ore from the Lake Superior iron ranges will be described. These ranges are remnants of mountains which have been gradually eroded and the iron in which has been deposited by percolating waters in almost pure beds of ore. To-day these deposits lie only about 70 feet below the surface of the ground, and can be reached most economically by removing the cover of earth and rock rather than by sinking shafts and running galleries. The commercial exploitation of these deposits on a large scale waited, as did the Panama Canal, for the development of the steam shovel and other engineering aids.

The deposits are of enormous size, being ordinarily about 300 feet deep and covering, in some cases, several hundred acres. In the Hull Rust and Mahoning mines, two of the largest ones, the ore beds extend for a distance of four or five miles without a break. This combination of enormous size, of remarkable purity, and of location near the surface has resulted in the development of these mines to the exclusion of all but the most productive in other sections. Over three-fourths of our domestic iron ore comes from these ranges, and more was produced there in 1923 than in Great Britain, France, and Germany combined.

Removing the surface material. — Before the iron ore can be extracted, the covering of earth, rocks, and vegetation which overlie the deposits must be removed. This in itself is a large task. The work is done by huge steam shovels which leave a great hole in the earth each time they are loaded. When removing this covering, the steam shovel dumps enough of the material ahead of it to form a roadbed for its own track which must be laid as it advances. Surplus earth is either dumped to one side or carried some distance from the mining operation and dumped. Some of these deposits become enormous in size and sometimes when deposited too close to the scene of mining operations, slide down in avalanche fashion and partially bury the cars that are used to haul the iron ore or knock them from the track. A comparison of the amount of dirt removed from the Mesabi Range and from the Panama Canal may give some idea as to the size of these operations. By 1920, slightly over 354 million cubic yards of stripping had been taken from the Mesabi Range; 240 million cubic yards of earth were removed in building the Panama Canal.

Description of a steam shovel. — Various sizes of steam shovels are used, but the larger kind will be described. One of these weighs 300 tons and will make a cut 40 feet in depth and 175 feet in width without being moved. It will lift the iron ore to a height of 50 feet to the waiting cars. The dipper on such a shovel holds sixteen tons. The steel boom or crane which swings the dipper from place to place is 85 feet in length and weighs 50 tons, and the dipper stick which fastens the dipper to the boom is 50 feet in length and weighs 18 tons. The steam shovel is operated from a heavy car which moves slowly along a track built on the terraces which are left around the sides of the large bowl which is formed as the iron ore is removed.

Removal of the iron ore. — The reddish brown ore is torn from its bed by batteries of steam shovels which work day and night for eight months of the year except when they must be stopped for repairs. Operations are suspended for four months of every year because the lakes are closed to navigation for that period. When one of the shovels digs itself into the ore it usually scoops out a hole 25 feet in depth and 50 feet in width. It lifts 16 tons in one shovelful, and lifts one shovelful each minute, making a total of nearly 1,000 tons per hour that is removed by each shovel. The ore is loaded by the shovel onto cars which are run down into the pit. These cars are operated in trains, the size depending upon the grade to be gone over in leaving the pit. Usually from five to twelve cars are in each train. The steam shovel moves forward slowly and leaves a terrace as it eats its way around the bowl.



Open Pit Iron Mine

In the Lake Superior iron-ore regions, a steam shovel scoops up the ore from open pits, filling cars at the rate of almost one a minute. The ore is then carried by car to the neighboring shipping ports on the lake and dumped into bunkers, from which it slides down chutes into the hatches of the ore ships. Over 3000 tons an hour are loaded in this fashion. Owing to the ease and cheapness of the methods and the purity of the ore, the Lake Superior region is now producing about three-fourths of the iron ore used in the United States.

Some of these bowls are very large. At the Hull Rust Mine there is one that is 320 feet in depth, 4,000 feet in width at the widest part, and 2¼ miles in length.

Transporting the iron ore. — After the loaded cars are pulled out of the bowl they are assembled into trains to be taken to the ore docks at Duluth. On the Mesabi Range, each train is composed of from 50 to 60 cars, each containing 30 cubic yards of iron ore. About 30 such trains are sent from the range daily during the working season. One large company, however, makes up trains of 96 cars holding a total of 4,800 tons of ore.

The ore docks. — When the trains reach Duluth, which is about 70 miles from the ore fields, they are run down to the unloading piers on the shore of Lake Superior. These piers are large platforms of concrete and steel built out over the water. The railway tracks are elevated on these piers and underneath the tracks is a series of pockets into which the ore falls as the cars are tipped. One of the largest of these piers is 2,004 feet in length, 60 feet in width, and 84 feet in height from the water to the level of its deck. This pier has 384 ore pockets, 12 feet from center to center, holding 153,600 tons each. The bottom of the pockets is 40 feet above the level of the water and each one is provided with a hinged spout, electrically operated. Through these spouts, the ore is carried by the force of gravity to waiting ore ships. Each pier is wide enough to accommodate two railway tracks.

Loading Ore Ship at Duluth

The ore is brought by train to the dock, where it is dumped into great pockets. From these it is run by gravity into ore-carrying vessels. In the illustration may be seen a number of lowered spouts down which the ore is pouring into the hold of such a vessel.

The ore ships. — These ships are huge steel shells about 600 feet in length by 60 feet in width, holding from 10,000 to 14,000 tons of ore. The hatches of each boat are 12 feet from center to center. The ore pockets are spaced at the same distance in order to facilitate the loading of the ship. When a boat is being loaded it is moved along from pocket to pocket so as to get the proper mixture of ores. At the smelters, particular furnaces require ore with a definite amount of certain impurities. Since the ore from the different mines will not all contain the same impurities nor the same amount of the different impurities, the various ore pockets may contain ore of a slightly different nature from the others. By loading the boat from various pockets, the mixture required can be obtained. The ore is then carried to the lower lake ports where it is either unloaded into the storage bins of the lake port smelters, or into railway cars it if is to be taken to inland plants. An ore boat travels about 40,000 miles during a season, which is from April 15 to December 15.

With the large equipment used, great amounts of ore can be loaded or unloaded within a short period of time. In one instance, 12,817 tons were loaded from the pockets into a ship in 16½ minutes. The ships are loaded by gravity, but lifting machinery is necessary to unload them. The equipment used is electrically operated jaws, built and operating on somewhat the same principle as a steam shovel. These jaws dig into the ore and lift 17 tons of it at one time. One minute is required for a complete trip by such a machine. If the ore is to be used at a lake smelter, the jaws deposit it in a long trough running parallel to the dock from which it is taken to the stockpile by 15-ton grab buckets operating on conveyor bridges 500 feet in length. At one time, 13,000 tons were unloaded from a single boat in 3½ hours.

The use of large shovels, cars, and boats and of powerful locomotives results in a great saving of labor, making the output from the open pit mines several times that from an average underground mine. The lake transportation is another item in the low cost of the iron ore mined. By this means the ore can be taken to the southern lake ports at a very low cost. If rail transportation only were available it is doubtful whether a very large amount of the Lake ore would be mined.

Conclusions. — The two kinds of mining described differ materially in organization and technique and may be profitably contrasted.

The bituminous coal industry, as at present carried on in the United States, is, first of all, very wasteful. The proportion of coal in the mine which is recovered and marketed ranges from 80 per cent in Virginia down to 51 per cent in Illinois; on the average there is a loss of about 35 per cent of the coal, of which half is avoidable. This loss is due to poor engineering methods in laying out the mine and in working it. " Rooms are abandoned," writes Dr. E. T. Devine,[1] a well-informed critic, " when demand for coal slackens, before they are worked out, allowing them to stand idle until the roof caves and the expense of reopening becomes prohibitive. Coal which might be taken out is left on the roof and bottom and in pillars. Pillars are left to protect oil and gas wells and to prevent subsidence of the surface, when back-filling or other means of accomplishing these same ends might be employed. Pit cars are loaded too high, so that coal falls off in transit and is ground under foot. Cars with poor doors or wide cracks are used, which let the fine coal sift out and stay in the mine, incidentally adding to danger from coal-dust explosions. Coal is used for ballasting track in the working places, and is wasted by careless methods of cleaning and by excessive blasting which blows small sizes into grooves or gobs."

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[1] *Coal,* p. 205.

Better practices usually prevail in mines under the control of larger companies, but the older mines, and the smaller ones, are still in a primitive stage of development. In the latter the coal mining industry is still carried on much like a domestic industry, with little use of machinery, antiquated and traditional methods of operation, in which the individual miner carries on a rough sort of craft work under a minimum of supervision. The methods described in the early part of this chapter are characteristic of the better and larger companies, but even in these the " factory system " has not been fully developed. In spite of the considerable use of mechanical devices, a more general introduction of machine loaders and of electric drilling would reduce the cost of mining bituminous coal not less than thirty per cent. The industry is moreover greatly overdeveloped, having a capacity of about 1,000,000,000 tons per year against a normal demand of perhaps two-thirds to three-quarters of this amount. If properly organized at least 200,000 miners could be freed from this industry.

The iron mining industry, as carried on in open-pit mines in the Mesabi region described in this chapter, stands in striking contrast with bituminous coal mining. Here large scale methods prevail, with the use of power machinery and labor-saving mechanical devices on a scale scarcely equalled in any other industry. The result is a high degree of technical perfection and a consequent reduction of costs. Perhaps in no other industry has engineering skill so minimized human labor or provided such a large quantitative return from human energy expended.

SUGGESTIVE QUESTIONS

1. What causes a vein of ore to disappear suddenly?
2. Are large scale mining operations in the interest of the conservation of mineral resources?
3. Find out why the production of petroleum proceeded so rapidly in California from 1923 to 1925.
4. How do you explain the presence of coal in a level region like Illinois?
5. Why is there so much unemployment in the coal mining industry? How might this be remedied?
6. Contrast the social and economic conditions in a temporary and a permanent mining community.
7. Is copper mining as dangerous as coal mining? Is gold mining? Explain.
8. Describe the wastes of coal mining.
9. The coal mines of the United States employ fewer men than those of England, but produce more coal. Account for this situation.
10. Go to a local coal yard and list the various grades of coal, and the characteristics and price of each.
11. Find out what kind of coal is being burned in the furnace or stove at home. In what respects is it unsatisfactory?
12. Would it be socially desirable to " free " 200,000 miners from work in the coal mines?
13. Find out how the iron ores of the Lake Superior region were formed.
14. How do you explain the great difference in the technique of the coal and the iron mining industries?

BIBLIOGRAPHICAL NOTE

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CHAPTER XIX

FISHING

Nature of the fishing industry. — Under the term fishing, are included all industries which are concerned with the taking of fish or animals from the water. Aquaculture, a somewhat broader term, is often used to designate all industries which cultivate and extract products from the oceans, lakes, and rivers; but as some of these industries are concerned with the extraction of minerals, as salt and fertilizer, or of vegetable materials, as kelp, a discussion of the industry in the broader sense is beyond the scope of this chapter. Attention will be confined largely to a discussion of the equipment and methods employed in catching the more important fish.

Fishing is one of the oldest pursuits of man and is the means by which nearly all peoples obtained a portion of their food supply before a settled and permanent system of agriculture was adopted. Even today, it is an important item in the diet of many people.

All of the important maritime nations have had the fishing industry as a basis for their greatness. The Phœnicians, early Greeks, Dutch, and British are examples. Japan may be cited as a present-day illustration. There, the population is so dense that few meat animals can be kept. Fish, which abound in the waters to the north of those islands, are caught in large numbers and take the place of meat in the diet of the Japanese. Fishing trains the fishermen to the sea, and makes them daring and fearless, qualities that are desirable in sailors who man the merchant marine and the navy.

Almost every reader of this book has doubtless at some time attempted to catch fish in a neighboring pond or stream with a rod and line. Or perhaps he has taken heavier lines and gone out in a boat on a larger river or lake to fish. Some people follow this pursuit in vacation for pleasure, others carry it on intermittently to supplement their incomes, and a few depend altogether upon this kind of work for a living. The larger fishing industry found on the Great Lakes and the ocean, at which people spend their whole time, is not essentially different from the above, except that the equipment must be more elaborate to capture the larger fish that are taken and to transport larger catches to canneries, drying and salting grounds, and to market.

In the majority of our industries, the methods and equipment used have changed and improved since earlier times, but not so in the fishing industry to any extent. To be sure the means of preserving the fish and preparing them for market have changed, but the methods of taking them from the water remain very much as they have always been. More powerful equipment, and in some cases improved equipment, has been introduced for lifting and hoisting the lines and nets, and larger vessels for taking the sailors to sea have come into use, but this is as far as the new methods go.

Fishing is an extractive industry, but it differs somewhat from the other extractive industries. In mining, that which is extracted cannot be replaced by man; in agriculture he must replace the elements that are taken from the soil if the soil is to maintain its fertility; the situation in forestation is the same as in agriculture, except that a second growth of forests will grow naturally if given time, although it is not generally of so good quality as the first growth. But in fishing, if man will employ the proper methods of extraction and limit the quantity taken, a steady supply of good quality will maintain itself.

Types of fisheries. — Fisheries may be classified broadly as, (1) salt water fisheries and (2) fresh water fisheries. Salt water fisheries may be divided into, (1) deep sea and (2) shallow water or shore fisheries. Fresh water fisheries are generally inland fisheries.

The principal fish caught in deep sea fishing are the cod, halibut, and whale. The most important shallow water fish are the shad, herring, salmon, haddock, mackerel, menhaden, sardines, oysters, clams, lobsters, shrimps, and sponges. The fresh water fish in the United States may be divided into three groups based on their origin: (1) Great Lakes fish, (2) river fish, and (3) small lake and stream fish. The chief fish caught in the Great Lakes are the white fish, lake trout, and sturgeon; in the larger rivers are found the buffalo fish and catfish; in the small lakes and streams the carp, bass, pickerel, perch, and trout.

There are numerous other species of fish in each of the above groups, some of which are used for food, but they are not caught so extensively and are not so valuable as those named.

Importance of northern fisheries. — For several reasons, the important fisheries of the world are located in northern waters. (1) The land area of the southern hemisphere is small and its population is sparse and the demand for large amounts of food is not so great as in the northern hemisphere. (2) Fish are more easily preserved in the cooler than in the warmer regions. The waters of the tropics abound in fish, many species of which are edible, but, until refrigeration came into use, they could not be preserved easily. (3) In many northern districts the cool climate prevents the development of agriculture. In many places there is also a poor, rocky soil in conjunction with the cool climate. This is true of Norway, New England, Labrador, and Newfoundland. This necessitates the use of fish as food in such places. It is also an interesting and important fact that the sea near such regions generally abounds in fish. (4) The converse of the previous statement is that other forms of food are generally plentiful in the tropical countries, obviating the necessity for the people obtaining any considerable portion of their food from the sea. (5) Fishing is also an industry that requires a great deal of energy on the part of those engaged in it. Northern peoples possess this quality in greater degree than those of the tropics. (6) Another reason is that the fish of northern waters are, in general, better food than those of the warmer waters.

Location of fisheries. — Within a given area of the sea, the exact location of fishing operations will depend upon two factors: (1) the habits of the particular species regarding spawning and (2) the location of their food supply. Many species lay their eggs in rivers or in the shallow waters near the shore and are caught when they come in to spawn. The salmon of the Pacific coast is an example of this. The young fish which goes out to sea will always return to the river of its birth to spawn.

In feeding, fish congregate upon bottoms called banks. These banks are shallow places from a few feet to two hundred feet in depth, where the light is not prevented from reaching the bottom of the sea. The presence of the light causes the growth of countless small organisms upon which the fish feed. Thus the fish are attracted to these feeding grounds and are caught there. Several of these banks are found between Cape Cod and Newfoundland, the largest one being the Grand Banks, the greatest cod-fishing region in the world.

Organization of the fishing industry. — The fishing industry is one of relatively small-scale methods, although some of the salmon canneries on the Pacific Coast are of fair size. But for the most part the work is done by men in small boats, the crew ranging from one or two to as many as twenty-five or more men, depending upon the size of the boat. A sailing vessel of sixty tons capacity requires a crew of about twenty-five men. Sometimes the fish are prepared for market by the crew on the fishing boat. In other cases, they are brought to shore for the wives and children of the fishers to prepare, while in still others they are sold to someone else who does this work.

Equipment used in fishing. — A great variety of equipment is employed by the fishing industry, depending upon the distance from shore of the operations, the species of fish, and the size of the fish. Small boats can be used near shore, but larger ones are needed for long voyages because of the danger of storms. The equipment in general consists of boats, ranging in size from small rowboats to sailboats and small steamers, and lines, nets, seines, buoys, markers, hooks, harpoons, traps, weights for sinking the nets, tongs, rakes, steam dredges, bait, wheels, and clubs.

Characteristics of the fishing industry. — Many fishing communities are so void of other resources that they depend upon fish alone for their livelihood. This exposes them to all of the dangers of any one-product region in case their product should fail. And occasionally the supply of fish in a region does fail for a period of years at a time. In some places, as in Norway, the fishermen both fish and carry on agriculture. This is true in other places, but in the large fishing centers the fishers work at little else.

In the second place, as will be shown in more detail later, the work is seasonal. Fish come to their spawning grounds only at certain seasons; in winter the colder regions are blocked by ice; and fish are better for food at certain times of the year than at others. For some species, the work of taking them from the water lasts for only a few weeks out of each year. Fortunately, the various species have different habits, and fishers can fish for one species at one season and for a different one at another, thus extending employment over a longer period than if they were dependent upon one species alone.

A third characteristic is the danger with which the fishers are beset on every side. The dangers are probably greatest on the

Grand Banks, and since this is one of the world's largest fishing grounds, they may be described. In the first place, the region is subject to dense fogs, due to the fact that the warm winds from the Gulf Stream encounter those from the cold Labrador current at this point. The fog results in numerous collisions between different schooners, and often the fishing schooners and dories are run down by large ocean liners, since these banks are in the North Atlantic Ocean route between the United States and Europe. Also, the men in the small dories sometimes lose their bearings in the fog and drift away never to be found. There are also occasional collisions with icebergs which bear down unexpectedly on the fishing craft. Storms and careless overloading of the small boats with the catch also drown many. These conditions are the worst of those on any fishing bank, but they show the dangers which a large part of the fishermen of the United States must encounter.

Another characteristic feature of the fishing industry is the type of people that are found engaged in it. They are a bold, fearless, roving type, probably somewhat broader minded than the people of other one-crop regions because of their meeting and associating with the fishers of many other countries on the fishing banks.

A fifth feature is the extent to which hand labor is utilized. There are some machines for letting out nets and hoisting the catch into the larger boats, but a great deal of the work must be done by human hands. This will be made more obvious in the descriptions of the actual fishing operations which follow.

Thus far the discussion has been of a general nature applying to the fishing industry as a whole. The remainder of the chapter will be a description of the various methods of catching fish as they are practiced by the fishers of the United States. A discussion of these methods for all fishing countries would take up too much space, but, since fishing operations are very similar the world over, a description of those of the United States may be considered as representative.

In this description of fishing, the purpose is to treat the different methods of fishing, rather than to take up the manner of catching each of the more important species of fish.

Fishing for cod. — Since the cod is the principal fish caught by the fishermen of this country, the methods of fishing for it will be discussed first. Three methods are employed: hand-lines, French trawls, and gillnets. The first is the oldest, but it has been supplanted largely by the second. The last is the newest and some think that it may supplant the French trawl, but old and experienced fishers scoff at the idea.

Hand-lines. — Under the hand-line method, each member of the crew goes out alone in a dory. He goes out some distance from the larger ship and throws in his line. The amount caught depends upon the frequency with which the fish bite. Sometimes there is a bite inside of a minute; sometimes the fisher must wait for as much as three hours. There is excitement when the fish, which may weigh as much as seventy-five pounds, is landed. It thrashes around and sometimes upsets the small boat. This method of fishing persists because, year in and year out, the individual fisherman can earn more money than under the other methods even though the owner or master of the boats may get less. The fisher is alone in his boat and does not have to share his catch with a companion.

French trawls. — A trawl consists of a long line, usually from 150 to 440 yards in length, with a large number of short lines with hooks on their lower end, spaced at intervals of from 4 to 6 feet. Often several of these lines are joined to make a series a mile or more in length and containing from 5,000 to 15,000 hooks. It was developed and used first by the French, hence its name. Under this method the larger vessels proceed to the banks and anchor there. These ships vary in size from 50 to 200 tons capacity. Some of them are schooners, but the majority are cutters and yawls. At the height of the fishing season, there are as many as 75,000 of these on the Grand Banks, belonging to the fishermen of the different nations that fish there, since these banks are in the open sea and can be used by the fishers of any nation. Each vessel has six or more dories from which most of the fishing is done, and each dory has a crew of two, one to row and one to take the fish from the line.

When the trawl is set it is anchored at either end and marked with floating tarred kegs which serve as buoys, one at each end. These buoys are joined by a thin line. The anchor, which is not very heavy, is fastened to the bottom of the buoy with a line and also to the end of the trawl. Each of the floating buoys carries a small flag of a distinctive color or else has a name or number painted on it. This is to enable each crew to distinguish its own trawls. It might be supposed that with so many ships and fishermen there would be a great deal of stealing, but there is little of it because it is considered a serious offence, the fishermen themselves exacting the penalty rather than depending upon the courts of law on land.

When the catch is to be taken, the dories go out, one or possibly two to each buoy with the others waiting along the line until their help is needed. When the buoys are reached, these are lifted into the dory. Then the men take the buoy line and begin pulling it in. Finally, the men in the intermediate dories see the trawl and seize it and lift it to the surface. The fish are then taken from the small lines and packed in the dories. If there are more than the boats will hold, they are left on the hooks or thrown back into the sea. After the hooks are cleared they are baited and thrown back for another catch. Small fish are used for bait and the line can be hauled in every 12 to 24 hours. This being done, the loaded boats are rowed back to the vessel where they are hoisted and emptied. Sometimes the trawl with the fish on it is towed to the vessel.

Gillnets. — This method is not employed much until about a month after the end of the season for line fishing, which has lasted from the end of May until November. The period for the use of the nets lasts from November until the middle of March and it seems to be an innovation introduced to extend the fishing season over a longer period of time.

The cod is easily caught on a hook, but it is very wary of a net except at spawning time when it is rather heedless of its surroundings. The position of the net is marked by buoys, as in trawling, but the method of anchoring is more complex. The anchor, which is heavier than that on a trawl, is fastened to the buoy by the buoy line. The buoy line is weighted at intervals by three large solid glass balls. At the lowest of these balls, which is down to mid-water, the single line becomes two lines, one running to the anchor at an obtuse angle and the other continuing downward to a fourth ball a few feet from the sea floor. Another line from the anchor to the fourth ball completes the triangle. This latter line continues until it reaches a fifth ball placed at the upper corner of the net. A whole row of these balls is threaded along the upper edge of the net which hangs perpendicularly and has but little freedom to sway back and forth because along its lower edge there is another row of balls each hanging from a separate cord. The net fills with fish in from 12 to 15 hours and is then taken to the ship and emptied. Sometimes a moored ship supplants one of the buoys.

Fishing for salmon. — Salmon are found on both the Atlantic and the Pacific coasts of the United States, but the Pacific Coast is the source of practically all that enter into commerce. There are numerous methods, both primitive and modern, employed to catch salmon, but the more important ones are the use of gillnets, purse seines, haul seines, trap nets, and wheels. The first has just been described and will not be discussed again.

Purse seines. — This type of seine is in general use in Puget Sound and northward from that region. The seine is about 1,200 feet in length, 150 feet in width at the center and 120 feet at the ends. The meshes are 3¾ inches in width. The bottom is weighted with small pieces of lead, the lines to which the lead is attached being about 10 feet in length. The purse line is made of 1½ inch hemp and the rings through which it is pulled are of galvanized iron, 5 inches in diameter.

Operations are generally carried on from gasoline powered boats from 45 to 55 feet in length and developing from 45 to 75 horsepower. These boats are built with round sterns on which there is a movable platform operating on a pivot and with a long roller at its back end. The seine is stowed on this platform in a way to prevent tangling.

When a school of fish is sighted, the boat goes close to it and a rowboat is launched with one man in it. This man takes the rope from one end of the seine while the larger boat circles around the school with the crew letting out the seine all the while. When this has been done, the power boat runs alongside the rowboat and takes the rope which the man in that has been holding. The ropes from both ends of the net are then attached to the small power winch or engine which is used to haul in the nets. The circle around the fish is narrowed and the slack of the net is stowed on the platform. There is a hole in the bottom of the net and this is gradually closed as the purse line is drawn in just as a handbag is closed by drawing up the purse string at the top. The fish are taken from the seine by a small dip net in the end of a tackle. It is lowered and scoops up a load of salmon, then it is hoisted, guided, and tripped, the fish dropping into the hold of the boat.

Haul seines. — The haul seine is used chiefly on the Columbia River. The nets vary in length from 600 to 2,400 feet. At one end it is about 50 feet in width and at the other 10 feet. The large bag in the center is about 300 feet in length. The nets are usually hauled in on the numerous sand bars that exist in the river.

Operations start as soon as the tide has gone out. The net is placed in a large boat with one end attached to a smaller dory. As the boat moves offshore, the dory comes toward the sand bar. The large boat circles around against the current and as it does so the net is spread out in a half circle. As soon as the dory men get to the bar with their end the other end is brought in. Several horses are then hitched to it to pull it in. Buildings are constructed on piles to protect the men and horses at high tide.

Trap nets. — Several varieties of traps are used for catching salmon, but only one of the larger traps in common use will be described. These are stationary affairs of webbing and wire constructed so that the fish will be guided into the enclosure whatever his movements are. The lead is first constructed. This is a straight line of stakes running at right angles to the shore to which wire or net webbing is hung from the surface to the bottom of the water. The " hearts " are then built. These are V-shaped affairs beginning a little inshore from the outer end of the lead and about 30 or 40 feet from either side of the lead. There is a series of these hearts, one leading into the other and each becoming progressively smaller as the main part of the trap is approached. The fish enter the wide end of the heart or funnel and pass through the narrow end to the next heart and so on until the last one is reached. These hearts are turned toward the lead and run in the same general direction as it does. The narrow end of the last or inner heart leads into the pot and forms what is known as the tunnel. The pot is a square compartment of the appearance of a large sack. It is built beyond and immediately joining the inner heart. It is hauled up and down by hand or by steam. The next apartment is the spiller and it is simply a container for fish. It is square and adjoins either end of the pot. A small tunnel leads the fish from the pot into the spiller from which they are removed to boats.

In removing the fish to the boats, the tunnel from the pot to the spiller is closed and the ropes holding the front of the spiller loosed so that the net wall drops almost to the bottom of the water. A tug then pushes a scow alongside the spiller and takes its position on the outside of the scow. A line from a derrick on the tug is then attached to the far end of a net apron called a brailer which is heavily weighted with chains. Next, a small boat is run inside the spiller and the men in it draw the brailer across the scow and into the spiller and let it sink. When the fish have gathered in this it is reeled in by a steam capstan, the net folding over as drawn from its far side and spilling the fish out on the scow. This process is repeated until the spiller is emptied. The undesirable fish are thrown out.

Salmon Fishing

The salmon are being taken from one of the traps.

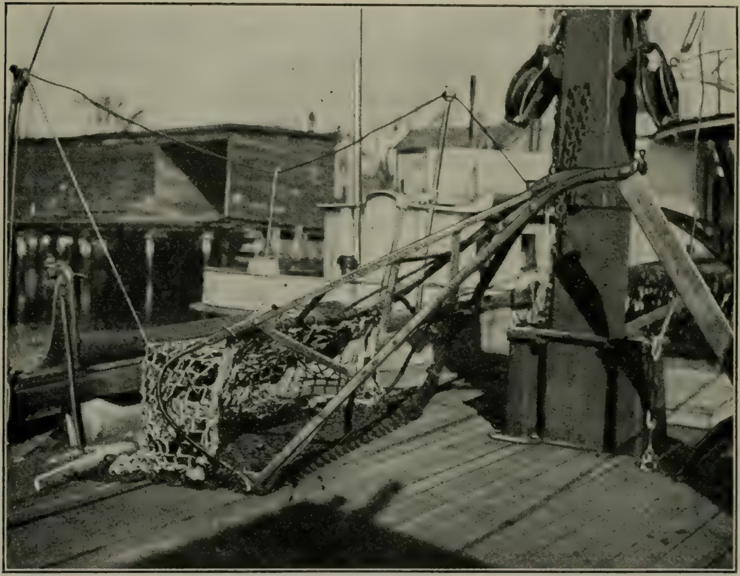
Wheels. — Fish wheels are either scow wheels which are movable, or shore wheels which are fixed. Either type is a large revolving wheel, similar to a water wheel, which catches the fish in wire buckets, fastened around the circumference, and throws them into a container, either a boat or a chute which leads to a storage bin. These wheels vary in size, ranging from 9 to 32 feet in diameter and 5 to 15 feet in width. The current of the stream revolves the wheel in either case. They are used chiefly on the Columbia River.

Fishing for mackerel. — Mackerel are caught by means of the methods described above, and also by weirs, traps consisting of a series of net walls arranged in such a manner that entry is easy but escape next to impossible. In constructing one, a sheet of netting buoyed and weighted like a seine, is stretched parallel to the shore. Running at right angles to this and into the sea is another net about 150 yards in length called the leader. At the other end of the main net is another net parallel to and about one-fourth the length of the leader. At the end of the third net is a fourth one which goes part way toward completing the square. Sometimes there are other nets placed at angles inside the square but there always remains a good wide opening for an entry. The fish may be either bailed out of the trap or shut in it until after the tide goes out, when they can be taken as they lie on the sand.

Fishing for oysters. — Oysters are found along the entire Atlantic and Gulf coasts, but the most important beds are in Chesapeake Bay and Long Island Sound. Baltimore is the greatest oyster-canning city in the world. The oysters are found in the shallow waters of bays and on the margins of coasts where there is a sandy or gravelly bottom to which the young may attach themselves. Water less than 130 feet in depth is best. The oyster-fishing industry employs about one-third of all fishermen in the United States. There are two ways of catching them, with tongs, and with dredges.

Tongs. — There are two types of tongs, hand tongs, and patent tongs. Hand tongs are operated by human skill and vary in size and length according to the depth of the water where they are to be used. In hand tongs, there are two long wooden handles varying from 7 to 20 feet in length, that are fastened together scissors fashion near the end that is to go into the water. To the short end of each handle a light iron bar, about 3½ feet in length in the larger sizes, and bearing rake-like teeth, is fastened at right angles. Above this bar are about six lighter bars, parallel to it and attached to the handles, the ends of the bars being fastened together by short wires. When the handles are closed this arrangement forms a basket-like affair about 3½ feet in length and 10 inches in depth. As the handles are worked back and forth, the teeth of the rake at the bottom are forced under the oysters as they lie on the sea floor. They are then lifted and dumped into the small boat in which the oyster gatherer stands.

Patent tongs are similar to the above except that the handles are of iron, are only about six feet in length, and are provided with an eye at the end for the attachment of ropes in lowering and raising them. They are used in water too deep for hand tongs and are raised and lowered by a spool or windlass. When being lowered they are locked open by a short hook which is released when they strike bottom. They are jerked with the rope several times when on the bottom to make the teeth sink more deeply.



Oyster Dredge

This is a power dredge used in fishing for oysters.

Dredges. — There are two types of dredges, small hand dredges and the heavier ones which must be hoisted mechanically. The hand dredge is a small bag-like net about 5 feet in length and 1½ feet in width, supported by a triangular iron frame. The bottom is composed of iron rings and the top of string meshes. On the front are iron teeth three inches in length and spaced at intervals of three inches. It is thrown overboard and allowed to scrape along the bottom for a few minutes after which it is hauled up, either by hand or by a hand windlass, and emptied. These are operated from small boats, usually three from each side of the boat. The oysters are culled on deck and then shoveled into the hold or into a pile.

The larger dredges are used on power boats. They hold from 15 to 30 bushels of oysters and are raised and lowered by the ship's engine.

Unloading the oysters. — On the boat, the oysters are shoveled into large buckets and hoisted to the wharf by hand with a rope and pulley or by means of a donkey engine and crane. They are either dumped on the wharf to await removal by wheelbarrows or directly into the wheelbarrows which take them into the cannery. Some companies lift the buckets directly to the storage room, in others an endless belt, lowered into the boat, carries the oysters inside as they are shoveled onto it.

Fishing for lobster. — The lobster may be taken along the whole Atlantic Coast, but it is found chiefly, as is the case with many other fish of a similar nature, in the vicinity of the Florida reefs. It may be caught throughout the year, but the best season is from February to July.

In fishing for lobsters, crews of two to four men go out in boats equipped with living quarters and with one or more small skiffs. These boats are all of the sail type, although a few of them have gasoline motors in addition. Each boat is also equipped with a well containing water in its center. As the lobsters are taken they are placed in these wells in order to keep them alive until they can be marketed. The wells on the larger boats hold as many as 1000 of the fish. The actual fishing operations are carried on from the skiffs, the larger boats being anchored, and the equipment used may be either a bully net or a pot. The former is used most.

The bully net. — This device is a small hoop net about 2 feet in depth and 1½ feet in diameter with a handle about 12 feet in length, and is similar in appearance to the small nets that are used for capturing insects. It can be used in water which is not deeper than the length of the handle, but in deeper water the pot must be employed.

In using this net, the men go out, usually at night, in a skiff, singly or in pairs. If it is necessary to use the water glass, they go out in pairs; if not, singly. The water glass is a glass-bottomed wooden bucket used to enable the observer to see the bottom of the sea if operations are begun in daylight. At night a lamp is fastened to the back of the boat to enable the fisherman to see into the water. When in use, the bully net is inverted with the net hanging over one side of the hoop. The hoop is put down over the lobster in such a manner that the fish is forced into the net. The bully net is then raised, with the net part and the imprisoned lobster hanging over the side of the hoop. The lobster is released by pulling the center of the net upward, allowing it to fall through the hoop.

Pots. — Lobster pots are traps of galvanized wire construction about 3 feet by 2 feet by ½ foot in dimensions, being somewhat similar to large wire rat traps. They are used in deep water and are generally weighted so that the trap will remain upright and not be jostled around by the tides. They are always set with the front directed against the flow of the tides. They are usually raised early in the morning and several lobsters may be taken at one time.

Fishing for clams. — The largest clam fisheries of the United States are located off the southwest coast of Florida near the Ten Thousand Islands. The industry is carried on continuously in some places, except for the stormy season which comes during August and September; in others it is carried on during the spring, summer, and fall months. Clams are taken by hand and by dredging. The former is a simple process, not being so profitable as the other and consists in the fisher wading about in the shallow water and sand after the tide has gone out, digging the clams out of the mud with a small, two-tined fork. He usually has a small skiff, which is emptied into a larger boat after being loaded.

Dredging. — Dredging was described in the discussion on oyster fishing, but as dredging for clams is done somewhat differently it will be described here.

The dredge boat resembles a house boat, and the boat as well as the digging machine is propelled by gasoline power. The digger has 10 rows of 6-inch curved teeth, placed on a revolving cylinder which operates much the same as a cylinder in a threshing machine. There are 18 teeth in each row and each row is about 6 feet in length. The rows of teeth are about 2 feet apart. The clams are dug out and carried upward by the curved teeth and on the downward turn are deposited on an endless wooden conveyor with strips across it to prevent their slipping backward. This conveyor is partly under water and the clams are partly washed of mud when they reach the top. At the top of the conveyor from two to four men pick out the live clams and throw them into baskets. Another person removes the filled baskets and puts empty ones in their places. The conveyor moves at the rate of about 1 foot per second, so the pickers are kept busy. When three buckets have been filled, they are placed on a car, taken to the end of the dredge, and loaded onto a boat which carries them to market.

The dredge boat itself is attached to an 800-pound anchor and moves by drawing in on a 1,200-foot cable which is attached to the anchor, about 1½ hours being required to travel the 1,200 feet. When the boat has been drawn in, it is allowed to drift back to a new position with the wind and tide, and the process is repeated. As many as 450 five-peck baskets may be dug in one day. The crew on such a boat consists of 9 men.

Sponge Fishing

The sponge fisher is shown pulling up a sponge which he has detached with a long handled rake. This is a tedious and uncertain method and is being supplanted by divers, who work under water in their diving suits.

Fishing for sponges. — Sponges as they are known on the market are the skeletons of a group of small animals which must be removed from the openings in the sponge after it is taken from the water. Sponges are found around the reefs of Florida and of the neighboring islands of the Atlantic Ocean and Gulf of Mexico. In taking them two methods are employed: diving and hooking.

Diving. — A diver's outfit consists of a 10 to 20-ton schooner equipped with living quarters and a place to deposit the sponges, one or two small machine boats, and a diving apparatus. There are two divers in a crew and each works for about two hours at a time when operating at a depth of less than 60 feet, as is usually the case. The sponges are gathered by hand and placed in a net basket which is emptied from time to time.

Hooking. — This is a cheaper method than the former in that it can be employed by one or two men, but many places are inaccessible to the hook. A hook fisherman has a sail sloop from 25 to 40 feet in length on which to live and store the sponges, and a small dory from which to work. The hook consists of a handle, about 15 feet in length, with 3 tines bent at right angles to it, at the bottom. These tines are hooked under the sponge and it is lifted to the surface. Unless the water is very smooth, the water glass must be used to locate the sponges.

Economics of fishing industry. — Aquaculture resembles agriculture in more respects than mere similarity of name. In neither one is it possible to introduce a high degree of specialization, much division of labor, or the economies of large scale production. A fisherman, like a farmer, must turn his hand to many tasks; he may devote himself exclusively to one kind of fishing, as say for cod, but even in this branch he usually performs different tasks in catching and preparing the product for market. There is a higher degree of specialization in such an industry as diving for sponges, but generally the crew of a fishing vessel does any and all kinds of work that are called for.

Hand labor is another characteristic of the fishing industry. For many of the operations, as for baiting hooks, it would be impossible to devise machinery, and even where mechanical devices are used, as in the manipulation of the nets, much hand labor is necessary. The nature of the industry is such that it can be carried on by a few men with a small capital, and the concentration of the work under a unified management or with labor-saving machinery does not yield such economies as to lead to large scale operation. It is moreover seasonal, the product is not uniform or standardized, and the demand is not so expansible as for many manufactured articles. For all these reasons the fishing industry will probably always remain a small-scale, hand industry.

Future of the fishing industry. — Because of the increasing population and the consequent pressure upon the land for food, it will become increasingly necessary to use the land for the production of grains and vegetables for man's direct use rather than for the production of fodder and pasture to feed meat animals. The latter constitute the most expensive kind of human food, both in money cost and in the amount of land involved. As that point is neared the use of fish for food will undoubtedly become more widespread; such is already the case in Japan. The supply can be greatly increased by stocking our rivers and inland lakes and ponds. In Germany carp are kept in small ponds, where they are fed like poultry and used as needed; altogether about 200,000 acres are contained in such waters. This points to the possibility of the utilization of our own inland waters in similar fashion. Improvements in the process of preservation have made possible the shipment of fresh fish to most parts of the country. There are also many kinds of fish, not now considered edible, which can be used for food; this was proved during the World War, when an effort was made to introduce into our dietary whale meat, shark meat, and similar unfamiliar things. The future should see a growth rather than a decline in this industry. After all has been said, however, too much reliance should not be placed upon this industry as the source of food for future generations. It is to-day of less importance for the whole world than the production of poultry and eggs in the United States.

SUGGESTIVE QUESTIONS

1. Make a report on the early fishing industry of the New England region.
2. What measures did Great Britain take to develop her fishing industry, and why did she wish to develop it?
3. Locate the important fishing grounds of the world. What are the principal species of fish taken in each?
4. List the important fishing countries according to the value of the product in the order of their rank.
5. What are the principal species of fish found in the tropical waters?
6. Find out the relationship existing between fish and the deposits of guano on the islands off the coast of Peru. Does this same condition exist elsewhere?
7. Find out the spawning and feeding habits of some species of fish found in your neighborhood.

8. What was done by the United States government during the World War to encourage the use of fish as a food? What degree of success was attained?

9. Why would it be difficult to apply large-scale operations to the fishing industry?

10. Find out the methods employed in propagating fish in hatcheries.

11. Recently, the number of fish off the coast of Norway has been declining. Do you know of any way to account for this?

12. In what form do most fish which are served in your home reach your house? How do you account for this?

13. It is said that oysters should be eaten only in those months in whose names the letter " r " appears. Why?

14. Do you think that aquaculture may properly be considered an industry? A genetic industry? An extractive industry?

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CHAPTER XX

LUMBERING

Nature of the lumbering industry. — Seventy-five years ago small sawmills existed at many places in the United States on streams where water power was available, and to these a farmer, needing lumber to build a new barn, would haul the logs which he had cut on his woodlot to be made into planks. The small local industry has expanded into one of considerable size and scope, but the essential principles have not been altered. The large logging companies differ from the old-time farmer primarily in the scope of their operations, in the utilization of better methods and appliances, and in the continuity of their work.

The lumbering industry, which in this chapter comprises both the cutting of the logs and their transportation to the sawmill, is an extractive industry. As usually carried on in the United States, it resembles mining, since the supply is exhausted by the methods of extraction. As carried on in Europe, it is generally a genetic industry; that is to say, the trees are gathered like a crop and provision is made for replanting the cut-over area so that the supply is never exhausted.

Location of lumbering industry. — For the most part, the world's lumbering industry is confined to the north temperate zone. There is not a very large amount of land, comparatively, in the south temperate zone, and a great deal of the existing area lacks the proper climatic conditions for the development of trees suited to industrial uses. Extensive forests grow in tropical regions, but they consist mainly of hard woods that are not suitable for lumber for general purposes and indeed for very few specialized uses. The arctic and subarctic regions produce some lumber, but there the cold prevents the trees growing to such a size that they can be economically utilized. The north temperate zone, however, comprises a large area of land over much of which conditions are adapted to the growth of fine forests.

Within the important forest regions, the industry is confined largely to rough regions whose soil is not well adapted to agricultural uses. On good agricultural lands, the trees are cut and not replaced. In the future, lumbering will be confined largely to the rough or swampy regions which will not grow grain and livestock so advantageously as they do trees.

Organization of the lumbering industry. — A tree passes through two and possibly three stages before it emerges as a finished lumber product: (1) logging, (2) milling, and (3) planing. The first stage only will be described in this chapter. The second consists of sawing the logs into lumber of various dimensions. Products of this stage can be found in the local lumber yards. For many uses a smoother surface is necessary than that which the lumber possesses as it comes from the saw-mill. Therefore the lumber may be run through a planing mill to remove the rough surface.

At present, the majority of mill owners operating on a large scale have their own logging crews. But sometimes a separate company cuts the logs and delivers them to the mills; and earlier there were separate companies of river drivers who transported the logs to a mill for the logging crew. But at present — and the tendency seems to be growing stronger — there is a concentration of these various processes in the hands of the lumber manufacturer. The reason for this is found in the important place occupied by transportation in the lumbering industry.

Transportation and the lumbering industry. — The bulkiness of lumber and its existence in rough and sparsely inhabited regions causes transportation to be an important consideration. It has been estimated that the carrying of forest products to the mill and to market represents more than 75 per cent of the total delivered cost of the raw material, exclusive of stumpage value.[1]

At first, in this country, transportation was easy and the industry could be carried on by small companies. When the forests were widespread and practically untouched, operations could be started along a river course and no trouble was encountered in getting the logs into a stream that would float them to the mill which, probably, was only a short distance away. But the gradual cutting down of the forests exhausted all the trees which were situated close to good streams. This necessitated going back into the forests away from the streams to obtain lumber. Other means of transportation were required and their cost, in conjunction with the gradual shifting of the industry, made it impossible for the small producer to provide them. Large companies control thousands of acres of forests. They can also afford to reforest the cut-over lands. This makes possible the building into the forest of railways which can be used permanently. Even if reforestation is not practiced, the large area of timber land makes possible the use of the railway for a number of years before it must be abandoned. Then it can be torn up and removed to another place. This is an advantage of which only a large-scale concern is able to avail itself.

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[1] Bryant, R. C., *Logging* (New York, 1923), p. 121.

The development and expansion of our national system of transportation has also made large-scale operations possible. The size of the available market determines largely the scale of operations of any business. In the early history of the nation when transportation was both inadequate and expensive, only local markets were available. Now there is a national and even a world market for lumber products. This has been made possible by the extension of railways to all sections of the country. The markets for the lumber of various districts have widened and enterprises can therefore afford to expand their scale of operations.

Products of the logging industry. — The products of the logging industry are sawn logs, pulpwood, tan bark, hewed railroad ties, poles, posts, piling, sometimes wood for fuel, and other minor products. Some of these are merely by-products of the main logging industry and are not saved by all operators, being wasted in some cases or left for some one else to harvest in others.

Trees and their uses. — The chief use of forests is for lumber for building purposes. The trees utilized are divided into soft and hard woods. The most valuable of the soft wood trees are the white pine, spruce, and hemlock of the northeastern section of the United States; the yellow pine of the southeastern part; and the redwood and Oregon pine of the Pacific coast region. Oak, hickory, maple, poplar, ash, and walnut are the chief hardwoods used. These are found chiefly in the central and Appalachian regions. Soft woods are used for making the frames and finishing interiors of buildings; the hardwoods for interior work in buildings, furniture, farm vehicles and implements, and small articles in general use.

A good lumber tree should possess a straight trunk and be free from branches and knots for at least fifteen feet above the ground. Nearly all trees cut for lumber are taken from the interior of the forests because there the shade prevents the growth of branches except at the top of the trees. Smaller trees and those unsuitable for high grade lumber are made into such articles as railroad ties.

Seasonal nature of lumbering. — A characteristic of the lumbering industry is its seasonal nature, although recently there has been a tendency in some sections to stabilize the employment. Since the work is seasonal, the lumberjacks, as they are called, must seek other employment during part of the year. They usually work in the wheat fields of the Middle West during the harvesting season and then return to the lumber camps during the winter months. The extent to which operations in the lumber industry are maintained throughout the year depends largely upon the means of transportation employed. If railways are used, work can be continued throughout the year. This is the case in the Lake States, the South, and the Northwest. If snow and streams are depended upon, work must be done when there is a good covering of snow on the ground and sufficient water in the streams to float the logs to their destination. This is the situation in the New England region.

Work preliminary to logging. — Before an operator purchases a tract of timber land he wants to know the amount of available lumber that can be used for different purposes. To ascertain this is the work of the " cruiser." He tramps over the tract and estimates the amount of standing timber and the amount that is suited to various uses. Then he returns and makes his report to the prospective purchaser, who buys or declines to buy, accordingly.

This being done, a group called the skirmishers come in who build a camp and the transportation facilities that are necessary. The camp is located in a healthful spot and consists of from six to nine buildings, all made of logs that are felled to make room for the camp. The ordinary camp in the northern forests consists of about sixty men, with from twenty-five to thirty-five horses.

While the camp is being constructed, other workers are busy providing the necessary transportation facilities. They first cut a broad trail through the forest to connect the camp with a railway which may be as much as five miles distant, or they build branch railways connected with the main one. They next open a road straight out into the forest and start branch roads on either side. Along these roads skidways are built of logs laid side by side on the ground, about five feet apart, and held in place by stakes. The logs as they are cut and snaked out of the forest are piled on these skidways and they remain there until hauled to a central point preparatory to their final journey to the mill.

Logging methods: the crews. — The size and organization of the crews for felling the trees and cutting them into logs vary in different regions. In the Lake region crews of two work under a saw boss who has general supervision of the work. The same plan is followed in the South. In Maine the "head chopper" is in charge of all operations until the log is ready to be started to the mill. In the Pacific region, each operation may be performed by a separate crew. A notcher selects the tree, two fellers cut it, the notcher then marks it off in lengths, and the buckers, working singly, cut the tree up into logs. Two or three buckers are required for each felling crew. Men are also needed in each case to burn the brush and transport the logs to the skidways. The whole group of workers is called a yarding crew.

Felling a tree. — The trees to be cut are selected and marked by the foreman of a crew or by the head feller. He then decides the direction of its fall. It should fall so that the least amount of injury will be done to itself and to other trees. A notch is cut in the bark of several trees to indicate the lane of its fall.

Next comes the felling crew, consisting usually of two or three men. First a wedge-shaped notch or undercut is made on the trunk near the ground in the direction in which the tree is to fall. This notch must be made skillfully because it guides the tree in its fall. It also prevents the trunk of the tree from splitting before it is completely loosed from the stump. After this is completed, the sawyers, one on either end of a cross-cut saw, start sawing into the trunk on the side opposite the notch, on a level with or slightly above the notch. As sawing progresses, wedges are driven into the cut behind the saw in order that the saws will draw back and forth more easily. Frequently kerosene is poured on the blade to remove the pitch. When the tree begins to fall, one sawyer withdraws the saw and both seek a point of safety.

Log-making. — After a tree has been cut, it must be worked up into logs of various lengths. This process is called bucking. But preparatory to this, a swamping crew, composed generally of the recruits of the lumber camp, trims the branches from the felled trees, throws the brush to one side, and cuts a path through the brush from the fallen tree to the road. The trunk of the tree is then measured off into lengths by the head sawyer, the length of each log depending upon the ultimate use of the lumber to be sawed from it and upon the means of transportation. From ten to twenty-four feet cuts are considered most advantageous and are recognized as standard by the lumber trade. But sometimes, logs of sixty feet or more in length are cut, the work of making them into shorter lengths being left to the saw-mill. This is especially true when the logs are to be made into rafts or in case of inferior timber. A better and cheaper raft can be made of long rather than of short logs. In the case of inferior timber, an experienced man at the mill can reduce the loss by having the logs cut there rather than having the men in the timber do it. When the logs are cut in the timber, they are usually three or four inches longer than the cut desired in order to make allowance for damage that may be done in transporting them and also for the fact that the saw, in cutting the logs, may not run perpendicular to the length of the log. At the mill each log is given a straight, bright end.

Equipment used in felling and log-making. — The equipment used in felling and cutting the trees into logs consists of an ax, a cross-cut saw about six feet in length (except for large trees when it may be as long as eighteen feet), several iron or wooden wedges, a wooden maul for driving the wedges, a measuring stick, and a bottle of kerosene. When the stumps are cut high, spring boards are needed for the sawyers to stand on.

During the early days of the industry, the ax was used almost altogether in felling and cutting the trees into logs, and it is still used for felling small trees, but for larger trees the ax and saw are both used. A loss of both time and lumber results when the ax alone is used. The use of the saw increases the amount that a saw crew can cut by about ten per cent in a day. [2] When the ax is used alone there may be a loss of twenty board feet of lumber in a spruce tree.

Power machines have never proved successful in felling trees, except in the South where gasoline-driven saws have been used when it was necessary to cut the trees at or near the ground. Various types of saws operated by steam, gasoline, electricity, or compressed air have been devised. The chief reason for the failure of such machines is their weight, which makes their movement through a forest difficult. Neither can they be removed quickly to escape damage when the tree starts to fall.

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[2] Bryant, as above, p. 106.

In log-making, saws called steam dagos, driven by compressed air, have been used successfully and have resulted in a great saving in time and labor. Nine men are required to operate such a saw, but it does the work of about fifteen men working by hand.

Transporting the logs. — In general, the transportation of the logs after they have been cut may be divided into three phases: (1) the snaking of the logs from the point where they have been cut to the skidways along the roads or branch railways; (2) the assembling of the logs from the various points in the forest at a central point called the banking ground, situated usually along the main railroad or near a stream; and (3) the moving of the logs from the banking ground to the sawmill. These distinctions may not be clearly drawn between all of the stages in every case, as when a branch railway connects with the main line. In such a case the logs may be loaded on the cars from the skidways and then the cars switched to the main line without stopping at the banking ground. If logging operations were situated deep in the forest, this would probably be the case, especially if they were carried on in a region where there were few streams and little snow. But if operations were near the main line, or if snow and streams were utilized, all three stages would probably exist. Various devices and machines are employed in accomplishing these operations. Those employed depend largely upon climatic conditions, topography, and the presence or lack of good streams.

Snaking. — Snaking, or skidding as it is also called, may be carried on by several different methods employing either human, animal, or mechanical power. If the distance is short, hand-moving may be resorted to. But generally the other methods are employed, although even then a great deal of human labor is always required in handling bulky, heavy logs. In all regions except those that are swampy and along the Pacific coast, animal power is used to a large extent to draw the logs from the stump to the roads that have been cut through the forests in various directions. In swampy regions, stationary donkey-engines, with a cable that winds around a large drum, are used. Along the Pacific coast mechanical power is employed almost universally as it has been found to be more economical than animal power.

To move the logs, they may be dragged along the ground or else may have one end placed on a sled or a 2-wheeled cart and be dragged in that manner. Where it is possible, several logs may be loaded on a large sled or on a 4-, 6-, or 8-wheeled wagon and be taken to the banking ground. At the skidways, the logs are put in large piles to await transportation to the banking ground. The method of loading them on the large sleds or skidways is interesting.

The logs are piled in a triangular shaped mass with each log of the layers above the first lying in the depression formed by the pairs of logs in the layer below it. The top layer consists of one log, the second of two logs, and so on until the bottom layer is reached. The height of the pile is determined by the number of logs that are placed in the bottom layer. A team of horses or oxen and a long chain are required to place the logs in their position. The chain is fastened to a stake with one end passing over the sled to be fastened to the logs and the other fastened to the team's doubletree.

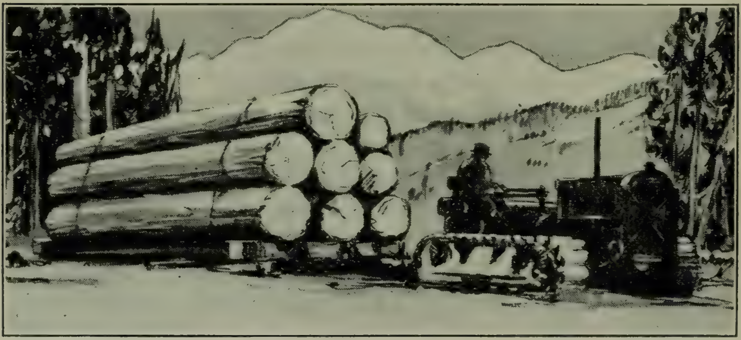
Then, as the chain is fastened in turn to each log, the team moves out at right angles to the sled and pulls the log up into its place, its movement being assisted by men with hooked instruments who guide it to its position. As each layer is finished two or three poles are placed with one end resting on the edge log opposite the team and the other end resting on the ground. This forms a sort of inclined plane up which the logs are pulled to the sled, thus making their movement easier for the team.

A skidding crew usually consists of about three teamsters, a swamper, and one skidway man. The animals may be driven singly or in pairs; frequently a teamster drives more than one team at a time.

Assembling at the banking ground. — This stage of transportation places the logs along the main routes of transportation which carry them to the saw-mill if the distance is long. In case of short distances, this stage may place them at the mill. But the former is usually the case. There are various means of accomplishing this part of the work. It may be done by means of large sleds, wagons, railways, slides, sluices, or aerial tramways. If power is needed, animals, snow locomotives, or tractors may be used.

A snow locomotive is a unique machine. Its front end is supported by a pair of bob-sleds which turn on a pivot, thus providing for the steering of the engine. Back of the sleds are two pairs of drive wheels that are mounted, like those of a caterpillar tractor, on heavy endless chains. It can be operated on a frozen road without the presence of ice or snow and it will haul as many as ten sleds of logs at five miles an hour.

A loading machine. — In case the railroad extends into the forest and the logs are to be loaded onto a car, specially constructed machines are used for this work. There are several types of these machines, but one of those in common use may be described. The loading device of this machine, which is operated by steam power, is so mounted that it will propel itself and the empty and loaded cars along the track; it will also snake the logs from the skidways along the track and load them into the car. It is mounted on a steel frame supported by four-corner posts, each of which rests on the ties outside the rails. The trucks which support the machine are so constructed that they can be placed out of the way when loading is going on, allowing the empty cars, as they are needed, to pass under the machine to their position beneath the lifting crane. A cable pulls the cars into position. Four men are required to operate this machine.



The Snow Locomotive

The wholesale lumber dealer's problems are simplified through the use of this powerful tractor.

Snaking and loading are done by means of cables operating on both sides of the track at the same time. In snaking, a long cable, with hooks on it like an iceman's tongs, is used. The hooks are fastened to the end of the log and the log pulled in as the cable winds around a large drum on the machine. The drums for each cable are so constructed that as one is being hauled in the other is being run out into the forest. The logs are loaded by the same cable after the hooks have been fastened to the center of the log. In loading from skidways beside the track, the logs are hooked at both ends, as this makes it easier to guide them into position. Such a machine loads logs much faster than could be done by any other means, and operates in places where teams could not work at all. Cars can also be loaded to their maximum capacity, which cannot easily be done when man and animal power are used. One of these machines will do the work of three crews of team loaders, and in case of hardwood, will increase the size of the load by about seventy per cent. It will load about fifty cars in a day.

Slides, sluices, and tramways. — In rough regions where other forms of transportation are impossible or impracticable, slides, sluices, and aerial tramways are used. A slide is a trough in the earth or is constructed of timber and is used to transport logs down a slope. An earth slide is made by dragging logs along the proposed route, which is thus cleared of obstructions. A timber slide may be built of logs or sawed timber. When made of logs, two rows of logs are laid side by side and slightly apart. The portion of the logs in the center of the trough are hewed to a smooth surface so that the logs will slide easily. When the slide crosses a place that has but little grade, it is necessary to tow the logs with horses or an engine. In cold weather some of these places can be iced so the logs will slip over them without the use of other power than gravity.

Sluices differ from slides in that they are generally longer and have water flowing in the trough to carry the logs along. They are operated by feeding crews, runners stationed at various points along the course, and by laborers to handle the logs at the terminal. If water is plentiful the sluices need not be water-tight, but if it is scarce efforts are made to save as much as possible.

Aerial tramways consist of a stationary, overhead cable fastened at each end with a carrier that passes back and forth along the length of the cable. Unlike slides and sluices, they can be used to transport logs up the slope as well as down. The carrier is lowered and brought back by means of a hoisting engine which winds the cable which controls the carrier around its drum. On some of the longer projects of this nature, there is a return line for the empty carriers. This permits the operation of a number of carriers on the same line.

By these different methods the logs are taken from the forest and assembled in huge stacks at the banking ground to await removal to the saw-mill by rail or water.

Moving the logs to the saw-mill. — Since the method of moving logs by rail on the main railroads of the lumber camp is similar to their movement on our large railroads, and is familiar to all, it will not be discussed here. Attention will be centered on transportation by water, which is more difficult and complex and more thrilling, both for those who conduct it and for those who read about it.

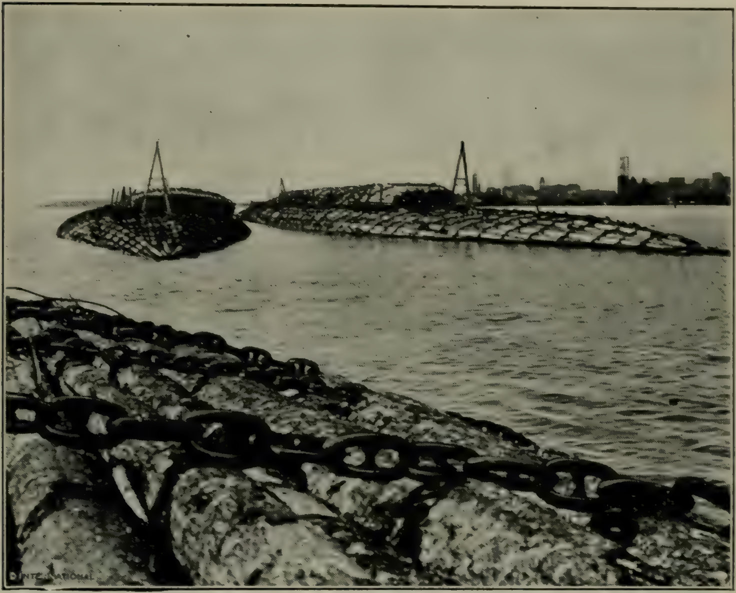
Logs moved by water may be transported singly or in a raft, which consists of a large number of logs bound together into one unit. On rough or small streams the former is used, but on the larger streams, lakes, and the ocean, the latter method is generally employed. On navigable streams, it is unlawful to float logs singly. Water transportation is employed in all parts of the country when sufficient water is available in the streams to float the logs. On the Great Lakes and along the Pacific Coast it is the usual practice.

In regions where the logging companies depend upon small streams altogether, or where they use these to supplement the railroads, the movement of logs must take place in the spring months when the melting snow and ice fill the stream with water. Or the logs may be held ready to let go after a heavy freshet has swollen the stream into a torrent for a few hours or days. Sometimes a pond or a stream may be dammed, and the water let out with a rush when needed.

Floating logs singly. — When logs are floated in this manner, they are put into the stream at the banking ground where they have been accumulated in large piles. Many times, the logs of several companies from several small streams are accumulated in large quantities in a main stream and the whole mass is moved co-operatively. Sometimes trouble may be encountered. The logs may form jams, or there may be obstructions, backwater, pockets, or shallow places which prevent the free movement of the logs. To break up jams, the drivers, as the men who are moving the logs are called, have to get to the front of the mass and with long pointed sticks and hooks try to dislodge the logs that are holding the others back. Often these break loose suddenly, imperiling the lives of the men who are trying to loosen them.

Sometimes they become lodged so tightly that dynamite must be used to break the jam.

To get around pockets, breakwaters, and obstructions of different sorts, booms are generally constructed to guide the logs. These are logs or long sticks of timber fastened together end to end and moored to objects on shore or in the stream. Booms are also used to confine logs at storage places, or at assorting gaps, and to await towing.



Fifteen Million Feet of Lumber

Each of these three log rafts is 835 feet long and 55 feet wide, and draws 28 feet of water; and each is held together by 175 tons of steel chains. The three rafts together contain fifteen million feet of lumber. The photograph was taken at San Diego, California.

As the logs of different companies become mixed, it is necessary to sort them out at certain points. The logs of each owner are distinguished by a mark placed on the log many times by the blow of a sledge hammer, which has the particular mark on it. Sorting is done at the sorting gap where the logs are separated and deflected into storage pockets which may line either side of the stream for miles. Here they await manufacture by the individual companies.

Floating logs in rafts. — When transported in rafts, logs do not get lost, and storage pockets are not required to catch them at their destination. Some rafts will move with the current, but when there is no current they must be towed by tugs. There are various types of rafts and the Federal Government specifies the type that may traverse certain navigable waters. They are made by binding large numbers of logs together in one mass by the use of chains or poles. In some cases the raft is made up of sections, the sections being held together by cables. A raft 70 by 150 feet contains about 750,000 board feet of timber. Rafts containing as much as 5,000,000 feet have been constructed.

Rail and water transportation compared. — The railroad has advantages over the waterway even though rail transportation is more expensive. In the first place the timber can be more fully utilized because there is not the danger of loss by sinking or stranding. Then rail transportation is more certain and steady. When a company is dependent upon a stream for transportation, it must accumulate a stock which can be used when the stream cannot be used. This increases the cost because of the large amount of capital tied up and because of the precautions which must be taken to protect the lumber from fire. A continuous waterspray during the danger season is employed by most companies as a precaution against fire. Moreover, when a river is utilized, the logs all come in at one season. The use of rail transportation distributes the supply throughout the year and does away with seasonal fluctuations. This is important for a region like the Southern States where operations proceed the year around. Rail transportation makes possible the transportation of all kinds of logs for greater distances. In the case of the hardwoods, river driving can be used only for short distances and then special measures must be taken to prevent the sinking of the logs.

Economics of the lumbering industry. — While the ownership of the forest resources is becoming concentrated in fewer hands, this does not mean that large-scale methods can be applied in the logging operations. More specialization can be introduced than in the case of agriculture or fishing, but there is not the possibility of the minute division of labor that is found in many of the manufacturing industries. Some of the workers have one task to perform but others of them help at the different operations involved.

Hand labor is another feature of this industry. In cutting the logs and moving them about, it has been impossible to get along without hand work and even when mechanical devices are used a great deal of aid is required from human hands. The seasonal nature of the industry, the great expense involved in transporting the logs in most places, and the nature of the product worked upon tends to keep logging operations from becoming large-scale and specialized, and prevents the substitution of machine for hand labor in many of the operations.

The future of lumber. — Were we dependent upon lumber for structural purposes, modern industry would not be possible; even with all of the substitutes that have been developed, there is much concern regarding a supply for purposes for which it is essential. Steel, stone, brick, and cement have replaced it largely in buildings, and vegetable fibers and wastes are being used to make substitutes in the manufacture of boxes and containers. One of the latest substitutes is the product that is made from bagasse, the crushed stalks of the sugar cane after the sugar has been extracted. Essential uses yet are in the manufacture of wood pulp, railroad ties, and interior woodwork for buildings; and for many other employments it is still cheaper and more desirable than any of the substitutes. With the extensive and generally wasteful use of lumber and the increasing need for it, the conservation of our present resources and the cultivation of new forests are becoming increasingly important. Our supply of lumber can be maintained and even increased if the proper methods are followed. More care must be exercised in the cutting of trees to cut only those which have reached sufficient size and to prevent the trees that are cut from injuring young ones when they fall. We must also stop the enormous waste from forest fires. When trees are cut others must be planted to replace them, as is done in Europe. And there are thousands of acres of land, fit for little else, on which trees might be planted. The application of these methods is certain to increase and cheapen our supplies of lumber and the future will probably see their more diligent application.

SUGGESTIVE QUESTIONS

1. From what species of tree is the most valuable lumber obtained? What are the other species of trees that furnish a superior quality of lumber?
2. Is there any relation between trees and the future of the automobile industry?
3. What are the optimum conditions for the growth of good trees for lumber?
4. Are logging operations large-scale or small-scale?
5. What prevents the more extensive use of the lumber of the Rocky Mountain region?
6. Find out the important foreign markets for lumber from the United States.
7. Describe what is meant by " soft woods " and " hard woods." What causes the difference?
8. Why should so many of the laborers in the logging industry be radical and socialistic in their views?
9. Comment on the knowledge that is required of a " cruiser."
10. What is " notching a tree " ?
11. List the dangers to which a worker in the logging industry is subject.
12. Read and report on the work that is necessary to maintain roads for logging sleds.
13. Is lumber becoming of more or of less importance in our industrial life?
14. What practices constitute good logging?
15. We place a tax upon the importation of Canadian lumber. Would it be better to let it in free and conserve our own?

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CHAPTER XXI

LIVESTOCK AND DAIRY PRODUCTION

Contributions of animals to human welfare. — In at least four ways domestic animals contribute directly to man's well-being. They provide (1) food, (2) clothing, (3) power or labor, and (4) they help to maintain the fertility of the soil.

It is probable that the first animal domesticated was the dog, and that this was for the sake of companionship rather than for any of the purposes just enumerated. In the case of all other domestic animals, however, the economic motive was predominant. Animals are, and almost always have been, an important source of food. In North America fully one-half of the products of human consumption, such as meat, milk, butter, cheese, lard, eggs, and similar articles, are derived from animals. A large part of the vegetation on the earth is unsuited for human consumption directly, such as by-products like straw and stover, but are consumable when converted into milk, butter, cheese, meat, and animal fats. It is estimated that eighty per cent of the corn produced in the United States is consumed by the live-stock in the county where produced, and marketed in the form of beef, bacon, pork, lard, and similar products. This conversion of crude farm products into food adds greatly to the quality of man's diet. Animals may be regarded as machines for changing plant into animal material.

Animals have also been a great source of clothing. Primitive man used the skins of animals as covering in the cooler regions, and, after the development of spinning and weaving, later made cloth from the wool of sheep, and hair of camels and goats. It is only comparatively recently that cotton has supplanted animal products as the principal clothing of the human race, and even today the conversion of wool and leather into clothing and footgear are leading industries in all industrial countries.

Power and fertility. — With the development of crop production the greatest economic problem which confronted primitive man was that of obtaining some kind of power with which to supplement his own strength. The use of animals as beasts of burden and for draught was accordingly added to their utilization for food and clothing. Although half a score of animals have served man in these capacities, such as the ox, cow, donkey, camel, elephant, buffalo, etc., probably no other creature has been so useful as the horse. Indeed, Professor Shaler thought that "the races of men may well be divided into those which have and those which have not the use of the horse." Today, railways, automobiles, and tractors have done much to diminish the importance of this use of animals in the more advanced industrial nations, but there are still large portions of the earth where the elephant, the camel, or the donkey are the principal burden bearers and transportation agencies, while the horse is still indispensable in most farm operations, even in the United States and Europe.

Finally, domesticated animals are of great importance in maintaining soil fertility. In a previous chapter[1] it was pointed out that every time a crop is taken from the land the fertility of the soil is proportionately diminished. If the fertility is to be maintained it is therefore necessary to restore the elements which have been removed. This principle has long been understood and practiced, and there are lands in Europe whose fertility has been maintained for 2000 years with the aid of animal manures. Indeed, it may be said that, except for overflow regions like the Nile valley, no agricultural region could continue to grow abundant harvests without the aid of manure from domestic animals. It has been estimated that a ton of average stable manure contains about $2.50 worth of plant food.

Improvement of animals. — The scientific and systematic breeding of modern livestock may be said to have begun with Robert Bakewell in England about 1764, and to have become important in the United States only about the middle of the nineteenth century. Disregarding the breeding of the beautiful Arabian horse by the Arabs, which came much earlier, it is evident that animal breeding is comparatively recent.

The fundamental principles in breeding, or improving the stock, are the same whether applied to plants or animals, but each has an advantage over the other in certain respects. In the case of plant breeding the selection of a good type is usually made from the seeds, which are only embryos and not mature individuals; and whose parentage may be doubtful; the result is therefore somewhat uncertain. But in the case of animal breeding the mature individuals may be studied, and the poorer specimens rejected while only the better animals are mated. On the other hand the breeder of plants has a distinct advantage in being able to work with large numbers of specimens which come to maturity more quickly. In animal breeding the rejection of the inferior animals, whether male or female, involves great expense; while the slowness of reproduction requires a long period of time to introduce any important modifications and then to fix these characteristics in a definite breed.

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[1] See p. 208.

Heredity. — This is a most important factor in breeding, and means the reproduction in the offspring of the characteristics of the parents and of even more remote ancestors. If a family or breed is well established it is more certain that the characteristics which distinguish it will be transmitted to the descendants. Once established, heredity tends to be persistent and certain; and a breed which transmits its special characteristics with much certainty is called prepotent. For instance, a breed like Hereford cattle, which has been bred pure for a century, represents a well-established type. Professor Plumb cites a striking instance of the transmission of a very desirable characteristic in the case of a Holstein-Friesian cow named DeKol Creamelle, which had a record production of 780.4 pounds of milk in a week; her daughter produced 750.2 pounds, her granddaughter 765.3, and her great-granddaughter 750 pounds in a week. This illustrates the old saying that " like produces like." The great breeders lay strong emphasis upon prepotency or power to transmit characteristics and make it, together with uniformity, the basis of most of their work.

Variation. — Not all offspring resemble their parents. Sometimes a latent or dormant characteristic, traceable to some remote ancestor, crops out, like the appearance of a black sheep in a white flock. Various names have been given to this occurrence, such as " atavism " or " throw-back ", but it is usually known as *reversion.* More rarely an entirely new characteristic shows itself, which has not hitherto been parent in either of the present lines of ancestry. This is called *mutation,* from a Latin word meaning change. An illustration would be the appearance of a hornless calf in a horned herd. Mutation may be valueless or even harmful, but sometimes a new and valuable variation from the parent type may be produced, as in the instance just given of a hornless calf. From such an individual might be bred a new type, as has actually been done in the cases of the Polled Jersey, Polled Hereford, and Polled Shorthorn cattle. These have been bred with such uniformity and for so long a time that well-defined breeds have been established. Similar illustrations in plant life are the seedless raisin and the navel orange. It is not necessary, however, to wait for an accidental variation; by careful mating and selection it is possible to modify characteristics, and improvements may be consciously brought about. More important than the modification of the environment, therefore, such as feeding, housing, and similar factors, is the selection of desirable parents for the unborn generations.

Selection. — There are two methods by which selection may take place — natural and artificial. Natural selection is the survival of those specimens which develop the best adjustment to their environment, through disease resistance, color protection, strength, fleetness or other favorable characteristic. One striking illustration of natural selection is the process by which wild animals become heads of herds or flocks. For instance the male deer or moose fight to determine which shall be master; the strongest survives and becomes progenitor of young deer to which he passes on his strength. Thus there is a constant weeding out of the weaker specimens and selection of the most fit, a process by which the vigor of the breed is maintained and increased.

Artificial selection occurs when man purposely controls the mating of animals and thus seeks to develop and perpetuate the characteristics which he has found most useful. Animal breeding is simply a systematic, methodical, carefully planned system of selection, which aims to accomplish certain aims. Marvelous results have been achieved by scientific breeders. Thus some strains of sheep have been bred for wool and others for mutton, horses for strength or for speed, cattle for beef or for milk. By variation, selection, and breeding it seems possible to produce almost any desired characteristic. Just as frost-resisting strains of wheat have been produced which will thrive in Siberia or northwestern Canada, so breeds of sheep have been produced, with the aid of selection, which can survive on the semi-arid plains of central Asia.

Grades of cattle. — The preceding paragraphs have described the methods by which the best types of cattle may be produced, but a word more may be added on this subject. Domestic animals may be classified roughly as pure-bred, grades, or scrubs. The pure-bred animal has a known pedigree and possesses certain definite and desirable qualities which he can be trusted to transmit to his descendants. A grade animal usually has a pure-bred sire, but a dam which is not pure-bred; if the infusion of good blood is large such stock is called high grade and may be practically as good as the pure-bred although they could not be registered in a breed registry association. Scrubs or mongrels are the common stock which has not been improved by selection or breeding. Since it costs just as much labor to maintain a scrub animal as a pure-bred one, while the difference in the yield may be enormous, it is manifestly poor business to use an inferior animal machine either as a producer of beef or of milk. Only under pioneer conditions, where feed is cheap, could it be justified.

The cattle industry. — From one standpoint cattle may be regarded as animal machines for making beef and milk, and incidentally other products like hides and manures. Just as in manufacturing industries, so also in the cattle industry it is necessary to have efficient machines, to have them run well and economically, and to obtain as large and as good a product as possible at the lowest cost. Many farmers devote themselves exclusively to animal husbandry, and even on farms where grain crops constitute the main pursuit, it is held to be the best practice to combine the keeping of livestock with general farming. Whether beef or dairy cattle shall be raised is a matter of individual choice, depending upon such factors as the scarcity and price of labor, the amount of capital available, the nearness of a market, the character of the land, and other considerations.

Classes of cattle. — All farm animals were formerly called cattle; now this term is applied only to beef and dairy animals or neat cattle, as they are generally called. There are thus two main classes of cattle, beef and dairy, but in each class there are many breeds. The leading breeds of each class in this country are:

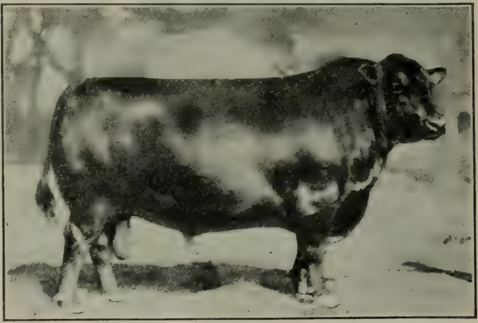
I. Beef Breeds

1. Shorthorn or Durham, from Durham County, England
2. Hereford, from Herefordshire, England
3. Aberdeen-Angus, from Aberdeenshire, Scotland
4. Galloway, from southern Scotland

II. Dairy Breeds

1. Jersey, from the Isle of Jersey
2. Guernsey, from the Isle of Guernsey
3. Ayrshire, from Ayrshire, Scotland
4. Holstein-Friesian, from Denmark and Holland

There are marked differences in the structure of the beef and dairy breeds, as may be seen from the accompanying figures. The beef animal is square and compact. Viewed from the side the top and bottom lines of the body run parallel, with the back quite level; viewed from front or rear the body should appear full and broad. Cattle of this type are often called "blocky." The general appearance of dairy cattle is quite different from that of the beef animals. A typical dairy cow shows a decided wedge shape whether viewed from front, side, or rear. The udder is most important, for upon the size of this depends the amount of milk produced. The beef cow usually gives little milk and the dairy type is not apt to produce either good or profitable meat. Each type of animal may be regarded as a machine for converting inedible plants into food fit for human consumption, the former into beef and the latter into milk and other dairy products. Just as mechanical machines are highly specialized, so these interesting animal machines have been specialized more and more until they have become most efficient instruments for the production of beef and milk. Each of these types or classes will be discussed in turn.

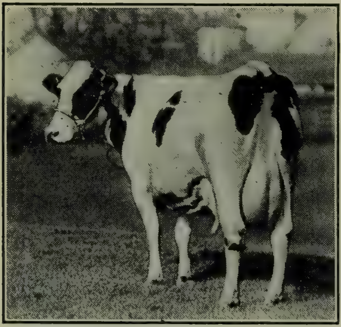


Oakville Quiet Lad, No. 109880

This is a good champion Aberdeen-Angus bull. Notice how perfectly he conforms to the beef type described in the text.

Breeding cattle. — There are three methods of handling beef cattle, which involve different amounts of capital investment and different kinds of feeding. These are (1) breeding pure-bred cattle,

(2) producing feeders or stock cattle, and (3) fattening cattle. The breeder raises cattle to be the progenitors of other cattle and not for sale as beef merely; their value is not measured by their weight nor by their market price as butcher's meat, but is far greater. Pure-bred cattle for breeding purposes are always more valuable than fat cattle for slaughtering, and this is the most profitable form of beef-cattle raising.



Pietertje Parthenea Tritomia, No. 234291

This is one of a pure-bred herd of Holstein-Fresian cows at the University of Illinois. It had a record, at 2 years and 60 days, of 15,786.4 lbs of milk and 539.5 lbs. of butterfat.

Since breeding cattle are not fattened for the market their feeding is comparatively simple. They should be kept in good condition so as to develop the inherited type and form to the maximum, but not allowed to become fat. This requires only a small amount of grain, but the best pasture in summer and plenty of roughage, forage crops and silage in other seasons when pasture is not abundant.

Production of feeders. — There is a large area of land lying east of the Rocky Mountains which cannot be plowed profitably and where grass is the principal crop. Here are produced cattle which are fed on grass and roughage, such as Kafir corn, sorghum, and alfalfa, during the first couple of years and are then sent to other regions to be fattened; large numbers of calves also are now shipped annually from the range country to the farm belt for fattening. These cattle are the so-called feeders or stockers. If the greatest success is to be obtained it is essential that the best types be used in producing feeders or stockers, for animals of superior merit will always command the highest prices. A statement so elementary commands instant assent when applied to manufacturing, where high priced articles require the use of the best materials and workmanship; yet many cattlemen expect to make a success of their business by using scrub stock. The quality of the cattle produced is determined primarily by the characteristics of their parents, and secondarily by feeding and care.

Feeders and stockers were formerly raised on the ranges, but the best ranges have now been fenced in and planted, and on the poorest ranges sheep are gradually replacing beef cattle. A great many farmers who follow a mixed system of stock and crop farming raise a few beef cattle for sale as feeders each year, but this is not usually profitable.

Fattening cattle. — The problem presented to the farmer who buys cattle in order to fatten them for the market is quite different from that confronting the breeder or the producer of feeders. The problem of heredity is beyond his control, except as he may confine his purchases to high grade stock and thus indirectly influence it. His sole concern is preparing cattle for the butcher, and this is a question primarily of feeding, although other factors such as age, shelter, etc., may influence the result. The food given cattle — or indeed any living organism — is used partly to maintain life, and partly to produce added growth or development along desired lines, such as the production of fat or milk or wool or physical strength. In order to produce added weight it is necessary to feed a ration more than sufficient to support life. But it is insufficient to regulate only the amount; the kind of food is also important. According to the results desired, foods richer in proteins, carbohydrates, fats, or other ingredients will be used.

Fattening cattle is generally carried on in sections where corn is the leading crop, and is one of the leading industries of the Middle West, but the methods will vary according to the feeds available, the season of the year, the probable demand for cattle when fat, and the experience of the feeder. Four different methods may be distinguished, namely, (a) producing "baby" beef, (b) grazing, (c) fattening yearlings and two-year-olds, and (d) preparing short-fed cattle.

Production of baby beef. — The majority of the cattle which are fattened for baby beef are bred on western ranges, shipped to the corn belt as weanling calves, and finished in corn belt feed lots. Such calves should be of superior conformation and quality, and in good condition for rapid and concentrated feeding so as to bring them to marketable condition as quickly as possible. They are sold when they weigh from 800 to 1200 pounds and at ages between one year and a year and a half. A great impetus was given to this method a few years ago by the high prices which were then being paid for beef, while another factor was the demand on the part of the packers for smaller animals, owing to the increasing demand on the part of the consuming public for smaller cuts of meat. This has been attributed to the growth of city and apartment house life, the decreased consumption of meat, smaller families, and similar factors. Even more important is the economy of production.

This method of fattening cattle probably yields greater profits to the feeder because of the character of the product. The growth of a young animal is much less concentrated, contains a much higher percentage of water, and is of less energy value than the gain in weight of more mature animals. These cattle are fed all they can eat, as they must be made to grow and also to fatten at the same time. The cost of producing beef is probably smallest by this method.

Grazing cattle. — It is the common practice to ship cattle into the grazing country about the first of May and to pasture them there on grass until they are fat enough to be marketed as grass-fat cattle during the late summer and early fall. The cattle are seldom produced in the grazing sections, but are brought in from the producing regions. Those used to convert grass into beef are usually the older and coarser specimens, the better types being selected to convert corn into beef. Summer grazing is practiced in the territory around Mineral Point, Wisconsin, and in the blue-grass sections of Virginia, West Virginia, Ohio, Pennsylvania, and Kentucky, and in eastern Kansas and Nebraska, but even in these regions the cattle are usually finished off with a corn ration.

Feeding yearlings. — The feeding of yearlings and two-year-olds is perhaps the commonest practice and is usual where no effort is made to force baby beef. In this case the cattle are carried through the summers on pasture, and are fed the first winter on dry roughage and the second winter are given corn and cotton-seed meal in addition. Cattle carried this far should weigh considerably more than baby beef when marketed.

Preparing short-fed cattle. — These are mature and heavy cattle which are given a heavy grain ration for about three months in order to put them in marketable condition in a short space of time.

Principles of feeding. — From what has been said it is clear that beef animals may fairly be regarded as living factories or machines in which plant food in its crude state is transformed into meat for human consumption. The principles which govern the management of this animal factory or machine are not essentially different from those which obtain in a manufacturing plant or mechanical machine, into one end of which are introduced pieces of wood or steel and from the other end of which come out clothes pins or watch springs or other products. In both cases the machines must be kept warm and clean and in good running order if they are to produce profitably.

Food given to an animal is used for two purposes: (a) for support or maintenance, and (b) for production. The food is used first to keep up the bodily heat, to repair the wastes, and to form new tissues (especially in young animals); these may be regarded as fixed charges, which may merely maintain the animal at a constant weight while at rest. After these needs are fully supplied, additional food will produce reserve stores in the form of fat and meat. Approximately one-half of the ration, when an animal is receiving a full feed, is required for simple maintenance. The profits from beef production depend, therefore, upon the rapidity and cheapness with which the other half of the ration is converted into meat.

Composition of fodders. — Fodders are made up of a large number of substances, each of which, to some extent, serves a definite purpose when used as food. These may be grouped in a few distinct classes, as follows: (a) water, (b) ash, (c) proteins, (d) carbohydrates, including fibers, and (e) fat.

Water is present in all fodders, although the proportion varies greatly, from 10 or 15 per cent in hay and grains to 90 per cent in some roots and green fresh forage. The water in the fodder supplies in part the needs of the animal for drinking water, and also adds succulence and palatability to fodders. Green fresh fodders are more palatable than the same feed dried; it is for this reason that silage, which has been kept fresh in a silo, is so much relished by cattle.

Ash is mineral matter which is obtained by the plant from the soil and is present in all plants. The proportion is generally small, but it is necessary to the life and vital processes of all animals.

The proteins, or albuminoids, constitute a very important group of substances, of which the most distinctive constituent is nitrogen. These fodders are therefore frequently called nitrogenous.

The amount of proteins found in the different fodders varies greatly and in many cases is less than is necessary to sustain life or promote growth. But those fodders which contain large amounts of proteins are sometimes more expensive than those deficient in these substances. The problem of successful stock feeding is therefore largely one of the sufficient and economical use of proteins. Nitrogen in concentrated form is found in cotton seed meal and similar concentrates and these are frequently fed in connection with hay and corn.

Carbohydrates consist of sugars, starch, and vegetable fibers, and constitute most of the dry matter of certain fodders. They are the main source of heat and muscular energy to the animal.

The fats of fodder serve much the same purposes as the carbohydrates, but are of more value to the animal.

What These Compounds Do in the Body[2]

Protein

1. Builds flesh, bone, blood, internal organs, hair, and milk
2. It may be used to make fat
3. It may be used for heat
4. It may be used to produce energy

Carbohydrates

1. To furnish body heat
2. To furnish energy
3. To make fat

Fat

1. To furnish body heat
2. To furnish energy
3. To furnish body fat

Mineral Matter

To furnish mineral matter for the bones, blood, hair, digestive tract, and other parts of the body

Water

To supply water in the body

Quantity of food required. — It has already been pointed out that the food required may be divided into two parts, a maintenance ration and a production ration. It is only from the latter that any profit is obtained by the feeder. The amount of food which an animal can use profitably, over and above that required for maintenance, varies according to the capacity of the animal, but in general a return will be obtained approximately in proportion to the food consumed, up to a certain point. Above that amount, the food simply passes through the animal without adding to its weight; or it causes disorders in the digestive apparatus and the animal refuses to eat. In other words the law of diminishing returns (page 3) applies to beef production just as truly as it does to other branches of agriculture, or to mining and manufacturing.

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[2] C. W. Burkett, F. L. Stevens, and D. H. Hill, *Agriculture for Beginners* (New York, 1904), p. 214.

The capacity to gain weight seems to be largely a matter of type. An experiment carried out by the Illinois Agricultural Experiment Station affords an interesting confirmation of this statement.[3] Six different market grades of steers, 16 in each lot, were fed the same rations. Combining the three best grades, called fancy, choice, and good, and the poorest grades, called medium, common, and inferior, there were two groups of 48 steers each. The average initial weight of those in the good group was 1,022.8 pounds, and that of the 48 common steers was 984. The average daily gain of the good steers was 2.48 pounds and of the common steers 2.10; the good steers consumed 11.37 pounds of dry matter for one pound of increase in weight, while the common steers consumed 12.66 pounds of dry matter for one pound of increase. This was a difference of 11 per cent in favor of the good steers.

Early maturity is also an advantage, because the largest daily gains are made early in life and on less food. "Averaging six different trials where accurate records were kept of gains and cost of food, it is found that during the first 12 months each 100 pounds of increase in weight costs $3.45; the second 12 months in the same animal, $7.42; and the third 12 months, $11.50. It is apparent, therefore, that if a steer can be made ripe for the market before he reaches the age of three years, the profits will be considerably greater."[4]

The conclusions to be drawn from these examples are clear. To produce a good product the best materials must be used; good stock will produce more and better beef than will common stock. But since beef production is a business carried on for profit, it is necessary also to produce it as economically as possible. A larger yield of beef for each dollar of outlay is obtained from good stock, and a more rapid turnover from early maturing stock. This latter factor means an economy in the amount of capital invested, a saving in interest charges and in labor costs, and hence a higher rate of return on the investment. The same economy has been obtained by bleaching cotton cloth chemically instead of exposing it to the sun, by ageing whisky electrically instead of by the slow processes of nature, and by many other industrial processes which have shortened the time required for production of goods.

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[3] Quoted by H. R. Smith, *Profitable Stock Feeding* (4th ed., Lincoln, 1910), p. 125.

[4] *Ibid.*, p. 126.

The dairy cow as a machine. — A modern dairy cow is a wonderful animal machine for the production of milk. A good cow of one of the established dairy breeds will produce from one to one and a half times her own weight of milk every month, and will yield her own weight in butter fat in a year. Such a cow will produce from 1000 to 2000 lbs. of milk monthly, or about 50 to 80 lbs. of butter fat. As a machine for converting plants into food fit for human consumption the dairy cow is much more efficient than is a beef steer. It has been calculated [5] that for each 100 lbs. of digestible matter consumed the dairy cow returns about 139 lbs. of milk, containing 18 lbs. of solids, practically all digestible; while the steer yields less than 10 lbs. of dressed carcass, which contains about 2.6 to 3.2 lbs. of water-free edible meat. Unlike the beef animal, which stores up in its own carcass the meat which it produces until its final utilization, the dairy cow gives up each day the milk produced.

One writer [6] even claims that the dairy cow is a more efficient machine than either the horse or the steam engine. A well nourished dairy cow uses about 43 per cent of the food she consumes for maintenance, 30 per cent for converting food into milk, while nearly 27 per cent finally appears as milk. Atwater [7] found that a man returned 19.6 per cent of the fuel value of his food as external work, and other investigations have shown that with animals at moderate work the part of the energy which appeared in external work varied from 28.8 to 36.6 per cent of the total energy expended. The best steam engines have an efficiency of about 20 per cent, while the average engine falls below 10 per cent. Gasoline engines range in efficiency from 18 to 25 per cent. Thus as a mere machine the dairy cow compares favorably with the best modern mechanical engines.

Milk is probably the most perfect single food in use to-day, containing, as it does, water to slake thirst, ash to make bone, protein to make flesh and muscle, fat and sugar to keep the body warm and to furnish energy, and vitamins to protect health. It is nature's first food for mammals, and is cheaper than meat at current prices. A pound of milk (slightly less than a pint) has about one-third the energy-value or calories, about one-half the protein, and an equal amount of ash as a pound of good beefsteak, and costs about one-sixth as much. One pound of sirloin steak contains 985 calories of energy-value, as against 278 calories in a pound of whole milk, 3106 calories in a pound of butter, and 1835 calories in a pound of full milk cheese.[8] The greater economy in production of milk as compared with meat, and the growing recognition of its food value, is leading to its increasing consumption. The amount of milk produced in the United States in 1923 was 110,000,000,000 lbs., valued at $2,500,000,000. The task of supplying our great cities with milk and other dairy products is one of the major problems in modern industrial life.

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[5] W. A. Henry, *Feeds and Feeding* (11th ed., Madison, 1911), p. 79.

[6] Jordan, *Rural New Yorker,* Sept. 9, 1899.

[7] U. S. Dept. Agriculture, Office Experiment Station, Bulletin 136.

The dairy industry: breeding. — There are about 22,000,000 dairy cows in the United States, which is approximately one to every family. They are found in largest numbers in those regions in which the population is comparatively dense and in which land, labor, and feed are comparatively high priced. Improvements in transportation, however, have made it possible to carry on the dairy industry at ever-increasing distances from our great cities.

There are three more or less distinct types of dairy farming: (1) the production of milk and cream for direct consumption; (2) the production of milk for butter and cheese making; and (3) the raising of pure-bred dairy stock for sale as breeders.

The last of these may be dismissed briefly, for the same principles obtain in the case of the dairy cow as were observed for beef cattle. The most profitable dairy cow is the one which is able to secrete the largest quantity of milk or butter fat from the least expenditure for food. The qualities which it is sought to establish and transmit are therefore very different in the case of dairy stock from those which are sought for in beef cattle. The principles of heredity, breeding and selection are, however, the same. Animals of pronounced and well-established dairy types should constitute the basis of the herd. Since there are considerable variations even within a good type, a record of production should be kept of each individual cow, both as milk producers and as breeders, in order that the undesirable animals may be eliminated.

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[8] Calculated from table in H. C. Sherman, *Chemistry of Food and Nutrition* (New York, 1923), p. 410 ff.

Some animals do not yield enough milk to pay for their keep and care; these are called " boarders."

Careful breeding and selection will sometimes produce astonishing results. A single example, from the experience of the Cornell Agricultural Experiment Station, may be cited. In 1875 the Station took over a herd of about 20 cows whose average annual yield of milk was about 3000 lbs. After years of careful breeding and selection the herd was so much improved that by 1892 the descendants of the original cows averaged over 7000 lbs. yearly. Another illustration of the effect of breeding is taken from the experience of the University of Illinois Agricultural Experiment Station. There a record was kept of the milk yield of ten cows, all sired by a pure-bred Holstein-Friesian bull, which came of a notable milk producing family. The yearly production of the daughters of this bull averaged 13,504 lbs. of milk or 468 lbs. of butter fat, which was 3908 lbs. of milk or 160 lbs. of butter fat more than was produced by the ten mothers at the same age.

The principal dairy breeds are the Jerseys, Guernseys, Ayrshires, and Holstein-Friesians; minor breeds are the Red Polled, Brown Swiss, Dutch Belted, and two or three others only slightly represented in the United States. Some of these are treated as dual purpose animals. It is difficult to say which is the best in a particular locality for much depends upon the local conditions and similar factors other than heredity. Tests of pure-bred cows of various breeds for the production of milk and butter fat were conducted at the Columbian Exposition in Chicago in 1893, at the Pan-American Exposition in Buffalo in 1901, and at the Louisiana-Purchase Exposition in St. Louis in 1904. Upon the basis of the largest daily return over feed cost the Jersey cows ranked first in the Chicago and St. Louis Expositions, and the Holstein-Friesians in the Buffalo Exposition. Pure-bred bulls of these breeds have brought record prices for dairy cattle; the Jersey bull Sybil's Gamboge sold in 1919 for $65,000, and the Holstein-Friesian bull Carnation King Sylvia brought $106,000 in 1918.

Milk production. — Since the objective in dairy farming is the production of milk and not of beef, the fundamental rule in feeding is to feed the cows enough to keep body maintenance, and in addition sufficient food nutriants to satisfy needs for milk production. A properly balanced ration will contain a larger proportion of milk-forming food (protein) for the dairy cow, while the beef animal requires a larger proportion of fat-making food (carbohydrates and fat). Dairy cows produce milk most economically while on pasture supplemented with some grain; hence they should be pastured as long as possible, and when this is impracticable, summer conditions should be approached as nearly as possible. This ideal may be nearly reached in those sections which have abundant pasture and low-priced alfalfa hay and corn, but in other sections the cows must frequently be stall-fed even in summer. Milk can be produced most economically where home grown feeds can be utilized to the best advantage.

The dairy farmer may be engaged in the production of milk for sale as whole milk or cheese or for manufacture into butter. In the former case he is more interested in the quantity of milk produced and in the latter in the amount of butter fat contained in the milk. While the dairy cow may well be regarded as a machine, the different breeds of cows have different inherent characteristics which cannot be changed by feed or care. Thus the Jersey cow gives milk which is relatively rich in butter fat, and the Holstein milk is relatively low in fat but is more abundant in quantity. The yield of any particular cow will, of course, be affected by any change in care, feed, or environment, but no changes can make a Holstein give milk like that of a Jersey or vice versa. The intelligent dairy farmer will therefore select his herd according to the kind of milk production in which he proposes to engage.

Whole milk for direct consumption is usually sold to a city distributor, and milk or cream for conversion into butter and cheese is usually sold to a creamery. The farmer's task ceases, therefore, with the sale of his milk, and the further processes in its utilization belong to the subjects respectively of marketing and manufacturing. These have no place in the present chapter.

The animal machine compared with the mechanical machine. — The preceding paragraphs have abundantly borne out the analogy of cattle to machines for the production of beef or milk. Just as the manufacturer has been able, out of pieces of iron and wood, to fashion machines for the production of specialized articles, so the agriculturist has been able, out of the scarcely less plastic living forms, to develop highly specialized animal machines for the production of beef and milk. The development of scientific cattle breeding, moreover, is scarcely older than that of machine industry, both dating from the latter half of the eighteenth century in England. Like the inventor, the breeder has constantly improved his animal machine, experimenting, rejecting, selecting, breeding for definite ideals, and succeeding finally to an astonishing degree. In this process there has been a high degree of specialization, the beef type and the dairy type, both descended from common ancestors, now exhibiting wide variations.

The progress which has been achieved in both these directions within the past 125 years may be illustrated briefly. The average weight of beeves slaughtered at the Smithfield market, in London, in 1795, was 800 lbs.; today a prime steer at the Chicago market will weigh 2000 lbs. The annual yield of whole milk of an average cow is about 4000 lbs., or about 160 lbs. of butter fat, which is certainly double what it was 100 years ago.

The animal machines differ in certain respects from mechanical machines. They are less likely to be displaced by new inventions or changes in fashion, but on the other hand are more perishable and subject to deterioration and fluctuation in output. In common with all animal and plant life they are subject to disease and death. While they have undergone immense improvement they do not respond unreservedly to man's inventive genius; no automatic milk producer can be expected. Man can only work along the lines laid down by nature. It will always be necessary for man to feed and care for the animal machine, although his work in those respects has been greatly lightened. Just as in manufacturing there is an immense difference between the best and the poorest plants engaged in production, so there is a wide variation among the animal machines; while in both fields there is a steady pressure to force out of use the inefficient instruments, this process works out more slowly in agriculture. In scientific farming, however, there is no place for " scrubs." We may fairly conclude that animal husbandry is an industry, subject not merely to natural forces, but governed by scientific principles as truly as any branch of manufacturing.

SUGGESTIVE QUESTIONS

1. In some densely populated countries, like China and Japan, there are relatively few domestic animals. In what ways, if at all, are the people of those countries affected by their absence?

2. The North American Indian had no domestic animals except the dog. Did this fact influence his development?

3. Find out how the different fancy breeds of pigeons came into existence.

4. It is said that the common ancestor of all the different types of dogs was a wolf. Is this possible?

5. Are the cattle in your neighborhood beef cattle or dairy cattle. Why?

6. Are they generally pure-bred or scrub? Why?

7. In what country did the majority of our breeds of cattle originate?

8. Does it seem to you that the comparison of a beef or a dairy animal to a machine is correct? Explain it more fully.

9. Did you ever belong to a pig club? If so, relate your experiences.

10. What are the desirable qualities of each of the different breeds of swine?

11. Which breeds of dairy cows are most prevalent in your district? Why?

12. Find out what the normal milk production of the average cow in your neighborhood is, and then compare it with the record production figures quoted in the text. How do you account for the difference?

13. If it is more profitable to have pure bred stock, why don't more, or all, farmers have them?

14. Hereford cattle are the most desirable of all breeds for the western ranges. What is the reason for this?

15. Is the number of livestock in the United States increasing or decreasing, proportionately? What is the significance of this condition?

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CHAPTER XXII

THE CEREALS

Cereals and grasses. — Cereals belong botanically to the large family of flowering plants called grasses, any grass that is grown for its edible grain being called a cereal. If to these be added the true grasses, grown in pasture or as hay and forage crops, we have a group of plants which easily ranks first in importance in the economy of mankind. The cereals constitute the principal food of most peoples, and even where these are supplemented by meat, the plants furnish much of the food for the animals whose flesh we eat. The cattle from the western plains of the United States or the pampas of Argentina convert the grasses of those regions into meat, as the swine in our central states convert corn into pork. Even wool and leather may be said to be converted grass.

The six great cereals of the world are wheat, maize or Indian corn, oats, barley, rye, and rice. Of these rye is the leading cereal of northern Europe, and barley of southern Europe, while rice is the chief cereal food of Asia. In the United States maize, wheat and oats are of the greatest importance, the other three cereals occupying a minor position. In the following discussion attention will be confined to the two leading crops in the United States, namely, maize and wheat.

Demand for wheat. — The historical origin of wheat is unknown, although it is supposed that its first cultivation began in Mesopotamia. Seeds have been found in the ruins of the dwellings of the Swiss lake-dwellers of the Neolithic period, and the Chinese seem to have cultivated it 300 years B.C. It was a chief crop in ancient Egypt and Palestine, and it was wheat that Joseph's brothers bought when they went down into Egypt.

Over one-third of the 1,600,000,000 people who make up the world's population are consumers of wheat bread, and the proportion is steadily growing. As each one of these persons consumes annually nearly one barrel of flour or about four and one-half bushels of wheat, there is a yearly demand for about

2,500,000,000 bushels of wheat to meet the food requirements of the human race. Although bananas, rice, potatoes, and some other soil products can support a larger population on a given area than wheat, they do not provide so high a standard of living. As the standard of living improves there is consequently a constantly greater demand for wheat, and even those countries which today depend chiefly upon rye or barley or rice are increasing their consumption of wheat. There are sound reasons underlying this general preference for wheat, for it has a high food value and it yields a vast number and variety of products. It is moreover easy to cultivate and to prepare for use; it adapts itself to widely varying conditions of climate and soil; and it yields a comparatively large and quick return. For all these reasons wheat has been called the king of cereals.

Classification. — In the centuries which have elapsed since wheat first grew as a wild plant many changes have taken place in its character, and many new varieties have been produced by its cultivation and selection under different conditions. It is estimated that there are over 1000 varieties to-day, but it will be sufficient to distinguish only six of these. Wheats are commonly classified as spring and winter wheat, red and white, hard and soft.

In the latitude of Kansas and throughout the corn belt in general the seeds sown in the fall live through the winter, but further north they are " winter killed " and hence planting in these sections must be done in the spring. The former is called winter wheat and the latter spring wheat. The winter wheat ripens first as a rule, but the grain of spring wheat is generally considered to possess better quality. About two-thirds of the wheat raised in the United States is winter wheat, but most of that produced in Canada and Russia is spring wheat. The center of the red wheat district in this country is from Kansas to the Red River Valley, while white wheat is raised chiefly on the Pacific Coast. The soft wheats, which are relatively rich in soft starch, are preferred for making flour, and the very hard varieties, which are richer in gluten, are used for the manufacture of macaroni. The hard durum wheat, first imported from Russia and now grown largely in the western states, is especially valuable for this purpose.

Wheat areas. — The great wheat field of Europe is the plain which stretches through southern Russia, although the Baltic region, Bohemia, and the plains of the Po and the Danube also yield heavy crops. In a normal year Europe produces not far from one-third of the world's wheat crop, but consumes about one-half. Great Britain consumes her entire crop in about three months; Germany consumes hers in about six months; and France produces almost enough to supply her own needs. Russia consumed but very little of her wheat crop before the war, exporting the major part to the deficient European countries. Czecho-Slovakia, Hungary, Rumania, and Bulgaria are also wheat exporting countries. Outside of Europe the great areas of wheat production and of export are the United States, Argentina, Canada, British India, and Australia.

Improvement of wheat. — Like every other living organism wheat is capable of variation and improvement. According to Professor Hunt [1] there are three steps or methods in the improvement of plants or animals, namely (1) inducing variation, (2) selecting forms having desired characteristics, and (3) testing the power of specific forms to reproduce themselves.

Variation. — Before a new variety can be produced there must occur a variation from the parent type. Such variation may be accidental or induced, that is to say purposely brought about by man. In this process two methods may be used, namely change of environment and hybridization. It is possible by modification of environment, that is by controlling the amount of water, of fertilizers, and similar items, to increase the yield of a crop, and this will always be part of the program of successful agriculture. But larger and more permanent results may be achieved by plant breeding. Although the scientific breeding of farm animals has long been carried on, it is only comparatively recently that attention has been given to the improvement of farm crops.

The second method of producing a new and more desirable variety is by crossing two unlike forms. If the resulting hybrid is more desirable than either of the parent plants then it will be retained and perpetuated. Crossing is also employed to combine two or more desirable characteristics, like hardiness and large yield in one plant.

A striking illustration of the benefits of crossing in order to combine two desirable characteristics has been cited by Professor J. R. Smith. [2] On the practically rainless plains of eastern Washington it is customary to let the wheat stand uncut in the field after it is ripe, and to harvest it with a combined thresher. The best yielding variety, however, permitted many of the grains to shatter out of the head and fall to the ground after it was ripe. The rival variety, which held its grain tightly, was so non-hardy that it was injured one year in three by frosts. By crossing these two varieties a third variety was produced with the frost-resisting qualities of the one and the grain-holding qualities of the other. This has permitted a great extension of wheat growing in the fertile Columbia basin.

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[1] T. F. Hunt, *The Cereals in America*, p. 19.

[2] *Industrial and Commercial Geography* (N. Y., 1913), p. 47.

Selection. — After variation has taken place the next step is to select the plants having the desired characteristics and to propagate these. This process undoubtedly has been followed by man, more or less unconsciously, ever since the domestication of plants and animals began. It is only recently, however, that scientific selection has been practiced. " One of the earliest experiments in selection of wheat was that of Hallett in England, begun in 1857.[3] He selected the best heads and kernels. The following table gives his results.

Year	Grains	Length	No. of grains	No. of ears on one stalk
1857	Original ear	4 3-8 inches	47	. .
1858	Finest ear raised	6 1-4 inches	79	10
1859	Finest ear raised	7 3-4 inches	91	22
1860	Heads imperfect	. . . .	. .	39
1861	Finest ear	8 3-4 inches	123	42

" Thus by means of repeated selection alone, the length of the ear was doubled, the number of grains per head was nearly trebled, and the tillering power was increased over fivefold."

By repeated and long continued selection enormous variations may be induced. In less than one hundred years of systematic and scientific selection by European sugar-beet growers the common garden beet, containing 6 per cent of sugar, was transformed into the sugar beet, containing 15 to 20 per cent of sugar. Similarly flax, corn, wheat, timothy, and other farm crops are being systematically bred for definite characters. Wheat has not been so generally improved by selection as has corn, but improvement is being made steadily.

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[3] P. T. Dondlinger, *The Book of Wheat*, p. 37.

Reproduction. — The third step in the process of improving the breed of plants is that of testing the power of specific forms to reproduce themselves. Most of them breed true to type, but a few will vary considerably from the type. In order to breed the varieties that have the desired characteristics it is necessary to find the individuals which vary in the right direction. If the number of specimens is increased there is greater likelihood of finding the desired individual. This is the method, apparently wasteful at first sight, by which Luther Burbank proceeded, growing millions of specimens and discarding all but a few.

Importation of improved varieties. — Some of the greatest improvements of wheat in the United States have come from the introduction into this country from other parts of the world of varieties which possess desirable characteristics. Russia has thus far contributed the most valuable importations. The famous red winter wheat of Kansas and the neighboring states was originally imported by the Bureau of Plant Industry of the Department of Agriculture from the Crimea in Russia. The characteristics which make it so desirable are high yield, hardiness to winter cold, good milling qualities, and great rust resistance. Disease resistance is generally sought and some remarkable successes along this line have been achieved.

Drought-resisting durum varieties have also been imported from eastern Russia and have succeeded well on the alkali plains west of the 100th meridian, where wheat growing with ordinary wheats is practically impossible on account of the light rainfall. The Russian varieties will ordinarily produce under these conditions, however, a crop of from 10 to 20 bushels per acre. Some Hungarian wheats have also been imported, together with white wheats from Australia, Europe, and the Orient, and have been introduced into California and other sections. In general the wheats from other countries succeed best in approximately the same latitudes in the United States.

Plant breeding. — The immense importance of plant breeding has been well stated by Luther Burbank in the following quotation:

" The vast possibilities of plant breeding can hardly be estimated. It would not be difficult for one man to breed a new rye, wheat, barley, oats or rice which would produce one grain more to each head, or a corn which would produce an extra kernel to each ear, another potato to each plant, or an apple, plum, orange or nut to each tree. What would be the result? In five staples only in the United States alone the inexhaustible forces of nature would produce annually without effort and without cost:

5,200,000	extra bushels of corn
15,000,000	extra bushels of wheat
20,000,000	extra bushels of oats
1,500,000	extra bushels of barley
21,000,000	extra bushels of potatoes

"But these vast possibilities are not alone for one year, or for our own time or race, but are beneficent legacies for every man, woman or child who shall ever inhabit the earth. . . .

"Cultivation and care may help plants to do better work temporarily, but by breeding, plants may be brought into existence which will do better work always, in all places and for all time. Plants are to be produced which will perform their appointed work better, quicker and with the utmost precision."

Soil treatment. — Man uses the land as an instrument of production in raising food and other agricultural products, but he frequently finds it desirable to make alterations in the soil so that it will better serve his needs. These soil alterations may bring about either a chemical or a biological or a physical change. The first is obtained by the use of fertilizers and of irrigation; the second by crop rotation. Purely physical changes are obtained by cultivation of the soil, which produces greater friability or openness, increased capacity for absorbing and retaining water and heat and a greater permeability to roots.

The physical condition of the soil must be such that the roots can penetrate it readily and that air can find its way in to it. Hard, baked, or water-soaked soils exclude the air and offer resistance to the growth of the roots. Cultivating, stirring, and breaking up the soil enable the air to circulate and the roots to penetrate through it. In a well cultivated soil about 50 per cent of the volume is space occupied by air and water. Tillage alone, without any other change in the soil, has been known to increase the yield of wheat over eight bushels an acre. "It is commonly assumed," writes Professor L. H. Bailey,[4] "that fertilizing the land is the most fundamental thing in agriculture, but this is not so; for if but one thing about farming practices were to be explained, that thing should be the tilling of the land."

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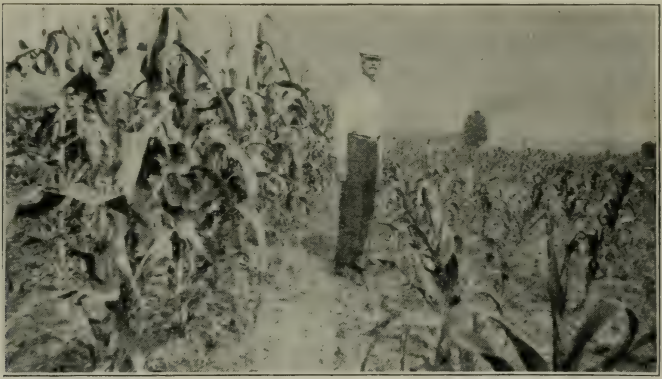
[4] *The Principles of Agriculture,* p. vii.

A crop of wheat of twenty-five bushels to the acre will take out of the soil 110 lbs. of nitrogen, 45 lbs. of phosphoric acid, 30.5 lbs. of lime, 14.5 lbs. of magnesia, and 142 lbs. of potash from each acre. It is manifest that these mineral elements must be in the soil in the first instance in order to produce a good crop, and that after they have been taken out they must be replaced or the succeeding crop will starve for lack of nutrient substances. It is necessary, therefore, to select a soil which naturally possesses the requisite qualities. Indeed Hunt says that "the character of the soil affects the yield much more than the quality of the wheat." Some types of soil contain in larger measure than others the necessary elements, although few possess all. It therefore is necessary to alter or amend the soil by introducing the missing or deficient elements or counteracting the effects of undesirable constituents. This is usually done by the application of fertilizers, which may consist of barnyard manure, or of commercial fertilizers in which the desired mineral



EFFECTS OF SOIL TREATMENT

Corn on the right is growing on untreated land, while that on the left is growing on land treated with limestone, manure, and phosphate. This picture was taken on the Raleigh Field at the University of Illinois Experiment Station.

substances are more or less scientifically combined. The soil may also be improved by plowing under a growing crop, especially the nitrogen-gathering legumes, as a green manure.

Crop rotation. — The rotation of crops is not only essential to the profitable use of commercial fertilizers, but it is practically equivalent to the application of a fertilizer. It was ascertained in 1886 that the root nodules of leguminous plants are inhabited by bacteria, which enable the plants to feed indirectly upon the limitless stores of free atmospheric nitrogen. Bacteria alone have the power of fixing nitrogen,[5] which is an essential condition to plant life. If a non-leguminous plant were placed in a soil destitute of nitrogen it would wither and die. It has therefore been found that a rotation of crops — in which leguminous plants, like alfalfa, soybeans, and clover, are introduced between the non-leguminous crops, like wheat, oats, and maize — will yield much better results than where the grain crops are grown alone. It has been found possible to increase the number of these helpful bacteria by inoculating artificially the seed of the legumes used; such inoculation consists simply in dipping the seeds in water which has been mixed with soil itself rich in bacteria.

Plowing. — The various processes used in the cultivation and harvesting of wheat may be described under the following heads: plowing, seeding, harrowing, harvesting, and threshing.

The first plow was simply a sharpened piece of wood or the crotched limb of a tree, and was designed to do a little more effectively the work previously performed by the hoe, namely, turning over and loosening the soil and killing the weeds. The modern plow is an evolution, gradual but far-reaching, from this primitive implement. Improvements have reduced the draft and friction to a minimum and different forms have been invented suited to different types of soil and kinds of motive power. In the United States the common hand plow, drawn by two horses, is most generally used, especially on the small farm. Another widely used form is the sulky plow, which has two wheels to carry the beam and a seat for the driver. With either one of these a man can plow from one to two acres a day, depending upon the condition of the soil. On the large farms the gang plow is usual, drawn by horses or tractors. This is simply a number of common plows combined in one frame.

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[5] The chemical methods of fixing the free atmospheric nitrogen for use as a fertilizer directly are described in Chapter XXIX.

The time of plowing differs in the spring and winter wheat sections. It is the usual practice to plow for winter wheat as soon as practicable after the previous crop has been removed. This destroys the weeds before their seeds ripen, and thus prevents vegetation making unnecessary demands. The pulverized surface soil absorbs and retains the moisture, and a compact seedbed is formed. In the spring wheat area of the United States fall plowing is usual. This only slightly increases the yield, but it is more destructive of weeds and insects and more economical in farm management than spring plowing. The depth of plowing varies with the climate and the nature of the soil, and is usually between four and eight inches.

Seeding. — There are three methods of sowing wheat: broadcasting, which scatters the seed rather evenly over the ground; drilling, which deposits it in rows; and dibbling, which drops a certain number of grains in each hill. Dibbling, which was once quite common in England, is never found now. Broadcasting, which was the first method of artificial seeding, has now given place largely to drilling. This is regarded as most advantageous for several reasons: " less seed is required, for the wheat is more uniformly distributed and covered. If it is sown at an even depth in moist soil, quick germination results. This places weeds at a disadvantage, especially in spring wheat. Drilling also decreases the danger from drought, winterkilling, and the blowing of soil by the winds." [6] There is also a larger yield, which will amply pay for the usual extra cost involved in drilling.

Seeding is done altogether by machinery in the United States. For broadcasting the wagon-seeder is the best machine; with this two men and a team can broadcast 100 acres a day. In the Pacific Coast states broadcasting is sometimes done by hand. For drilling the press drill is the best machine; with such a machine, covering twelve feet, one man and four horses can sow 30 acres a day, and no subsequent cultivation is necessary. By the old method of sowing by hand, one man could seed about 16 acres in a day, and the wheat had to be cultivated into the ground after sowing.

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[6] Dondlinger, p. 66.

Cultivation. — After the ground has been plowed once, it is customary to harrow it. This has the threefold purpose of killing the weeds, of leveling and pulverizing the surface, and, where it is done after sowing, of covering the seed. When wheat is drilled, the covering of the seed is performed in the act of sowing. In the United States, as in most countries, wheat receives no cultivation between sowing and harvesting, and harrowing is done before sowing in order better to prepare the seedbed. The simplest form of a harrow is a wooden or steel frame with teeth of wood or iron, but later improvements are the spring tooth and disc harrows.

Harvesting. — In wheat raising the climax of the year's work is reached at the harvest period. The wheat must be promptly harvested when it is ripe, usually within two weeks except on the rainless Pacific Coast. If it is not gathered then the fruit of all previous toil may be lost. Delay means possibility of loss through shelling or lodging by the wind, sprouting from rain, or destruction by birds. Before the invention of harvesting machinery, harvesting was the most burdensome and imperative operation on the farm, and its completion was marked by a harvest-home celebration. Even today it is an exacting and anxious time. Owing to the need of haste workers are brought into the wheat fields from outside. Many migrant harvesters begin their work in Oklahoma in June and move gradually northward as the wheat ripens until they finish in Canada in September.

It is a general practice to begin harvesting before the grain is quite ripe, as it matures after being cut and the yield is not diminished, while the harvest season is lengthened. Professor Hunt states [7] that a good test for judging the time for harvesting wheat is, that the kernel should be " soft enough to be easily indented with the thumb nail and hard enough not to be easily crushed between the fingers."

Harvesting machinery. — The improvement of agricultural machinery has been an important factor in economic progress, and in no direction has it been more marked than in the implements for reaping grain. The first of these was the sickle or reaping hook, which was used with one hand. The scythe, which was used with both hands, was a great improvement, and a further step forward was taken when the cradle was added. It is estimated

[7] P. 103.

that with a sickle a man could reap one acre in a day, while with a cradle he could cut four acres a day.

Both of these depend upon human muscles. The next improvement was to devise machines operated by non-human power. Of these there are four types in the United States at the present time used for harvesting wheat: (1) the self-rake reaper; (2) the self-binding harvester; (3) the header; and (4) the combined harvester and thresher.

All machines which cut the grain and gather it in bunches or rows are called reapers; in the self-rake reaper the rake deposits the cut grain in one side in bundles, which must then be bound by hand. It is used only where small quantities are to be harvested. An ordinary day's work for a man and team is from six to eight acres.

All machines which deliver the grain bound in sheaves are called binders. The self-binding harvester does away with the slow and laborious process of handbinding, as it binds the cut grain automatically into bundles and deposits these in piles. The major portion of the area devoted to small grains in the United States is now harvested by this machine. One man with three or four horses will ordinarily harvest from ten to twenty acres in a day, and two other men are required to shock the cut grain, that is to stand the bundles heads-up in groups of eight to sixteen.

The header and combined harvester can be used only in dry climates, like that of our Pacific Coast states, where the wheat is harvested after it is fully ripe and thoroughly dry. These machines simply chop the heads off the stalks, leaving the straw standing in the field. The header conveys the headed grain to a wagon which carries it to a threshing machine; or it may be put in stacks and threshed later. An ordinary day's work for a man and a team of eight horses with a header is from 15 to 50 acres.

The combined harvester and thresher is the most wonderful of modern harvesting machinery, and is the culmination of a long series of inventions. It cuts, gathers, threshes, cleans, and even sacks the grain without the touch of a human hand. On one side of the machine the standing grain is cut, and on the other side it is dropped at regular intervals in piles of filled and tied sacks, ready for the market. Every operation, except that of sewing up the sacks, which must be done by one of the operators, is mechanically and automatically performed by the machine itself. It can be driven by either horse or tractor power. A standard horsepower machine requires four men to operate it, is drawn by 24 to 40 horses or mules, and harvests from 25 to 45 acres of wheat per day. The steam or gasoline harvester requires eight men to operate it, and harvests from 75 to 125 acres per day.

Threshing. — Threshing is the process of separating the grain or seed from the hull or chaff which covers it. This is done not only for wheat, but also for rye, oats, barley, rice, flax, timothy, millet, buckwheat, beans, and peas. This was originally done by having animals tramp out the grain on a hard floor, and later by beating the grain with a flail. The grain was separated from the straw by raking and from the chaff by throwing it in the air and letting the wind blow the lighter chaff away. The same principles, striking, gravity, and a current of air are still used in the modern threshing machine.

This machine performs four operations: it loosens the kernels from the heads; it separates the kernels from the straw; it removes the chaff; and it delivers the clean grain in one place and stacks the straw in a pile at a distance. These operations are mechanical and automatic. The threshing machine is usually used where the grain has been cut by a binder and left in shocks on the field. A common type of machine requires four men to operate and threshes from 500 to 1000 bushels of wheat per day.

Storing wheat. — After wheat is threshed and before it is marketed it is frequently necessary to store it. In the United States this is commonly done in elevators; these are great granaries, built of wood in the country and capable of holding from 20,000 to 40,000 bushels, but constructed of steel and concrete at terminal points and holding about 3,000,000 bushels. Elevators have immensely facilitated the handling of wheat and other grains, as these are treated like water, being elevated to the top of the elevator by powerful machinery, and from that point run by gravity to cars or vessels waiting to be loaded.

At this point the farm operations in the production of wheat come to an end, and generally the farmer's interest in it, for he usually sells the wheat in the elevator or, more exactly, he probably sells the certificate showing ownership in a certain amount of wheat in the elevator. The next problems are those of marketing, which are met by another set of operators and which lie beyond the scope of this chapter. (See Chapter XXXVIII.) This wheat, which is a finished good to the farmer, is a raw material to the purchaser of wheat, the miller, who grinds it into flour. But milling is a manufacturing process and will be described in a subsequent chapter. (See Chapter XXX.)

Conclusions as to wheat growing. — In the United States wheat always has been, and still is, grown on cheap and fertile soil. The land has been a more abundant and less expensive factor of production than the labor involved. Every effort has been made, therefore, to economize labor, while the land has been used prodigally and with little thought for its conservation. This has led to extensive farming, that is to the application of only a small amount of labor and capital to each acre of land; or, to put it the other way, to the use of a large amount of land for each unit of labor and capital employed. Wheat in the United States has been a frontier crop, because it could stand transportation, and has been grown by extensive methods. It has been grown for export in competition with the rest of the world; about 75 per cent of the wheat is shipped out of the county in which it is grown and about 20 per cent is shipped abroad.

Land is cheap and plentiful, but labor is dear and scarce. In this fact is to be found the explanation of the large use made in this country of labor-saving agricultural machinery, and in no field is this better exemplified than in wheat growing. Practically the entire work of production, from preparing the seedbed to threshing the harvested grain, may be accomplished by machinery. Another striking feature is that the power to operate this machinery is derived from non-human sources, that is, from horses and mules or from steam and gasoline engines. Human labor is economized throughout all of the operations.

On the other hand, wheat growing, like most agricultural pursuits, lacks the other distinctive marks of capitalistic undertakings. There is little division of labor, except perhaps in the case of the threshing gangs and even there it is not carried far. In certain sections, as in the Red River Valley and on the Pacific Coast, large-scale farming is practiced, with its resulting specialization and economies of operation, but for the most part the unit of operation is a one-man farm. Where science and invention are invoked to assist man the best results are obtained, rather than where traditional rule-of-thumb practices are followed.

Maize. — Indian corn or maize, as it is more properly called, is a native of the American continent. Next to meat it was the chief food of the American Indian, and next to wheat it is the chief food-stuff of the American people today. It differs markedly from wheat in its limited geographic and climatic distribution. It thrives in the central Mississippi Valley, but not near the coast; in Italy, Austria, and the Balkan Peninsula, but not in Great Britain or Germany; it is an important crop in Australia, South Africa, and Mexico, and to some extent in Argentina. In the United States two-thirds of all the maize raised is grown in the seven states of Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska — a broad strip of territory across the north central Mississippi Valley known as the "corn belt."

"Among the causes limiting successful cultivation are temperature and sunshine, rainfall and physiographical features, including soil. It is only when these several factors are properly combined that the culture of maize becomes commercially successful. The absence of any one may limit successful production. If, for example, the area between the 70° and 89° July isotherm be followed around the world in the northern latitude, it will be found that throughout the larger part of its course the rainfall is insufficient at those times of the year when it is most needed by the maize plant; or, where the rainfall is sufficient, physiographical features prevent the culture of maize on a large scale.

"The so-called 'corn belt' of the United States appears to have the best combination of temperature, sunshine, rainfall, soil, and topography for the production of maize of any considerable area in the world. . . . It is this limited distribution, coupled with the fact that maize will produce about twice the food nutrients of any of our cereals per acre, that makes lands especially adapted to the cutlture of maize command relatively high prices." [8]

Ideal conditions for maize production. — The ideal climate for maize is one with a summer four and a half months long, hot in the middle season, with abundant sunshine. Water is most important for the successful cultivation of maize, the best results being attained when there are comparatively heavy rains at considerable intervals with clear sunshiny weather between. A soil that permits the free movement of the water through it in all directions is also essential. In order to maintain the fertility of the soil, a rotation with wheat or oats and leguminous crops is desirable in the corn belt. While maize is not an exhaustive crop it is the usual practice to use fertilizers along with rotation in order to keep the land in good condition.

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[8] T. F. Hunt, *Cereals in America,* pp. 202–203.

Varieties. — There are probably one thousand named varieties of corn, but only a comparatively few are grown in large quantity, and all of these can be reduced to five main types. These are pop, flint, dent, soft, and sweet. Pop corn has the peculiar quality of exploding into a snow white fluffy palatable mass when exposed to a high temperature, and is grown for human consumption. Sweet corn is extensively raised for cooking and eating while in the milk stage, and forms the basis of a large canning industry in the North Atlantic and North Central states. Soft maize was apparently widely raised by the Indians because of the ease with which it could be crushed, but it is not now grown for commercial purposes in North America. The dent and flint types furnish all the field corn of commerce, as well as practically all the corn fodder and silage. Almost all of this is of the dent type, the flint corn being grown only in the more northern latitudes or higher altitudes where dent corn will not flourish.

Improvements of maize. — Corn contains more fatty substance, or natural oil, than wheat; from this a salad and cooking oil is obtained, and from the oil various other products are prepared. It also contains a considerable amount of protein, which is valuable for feeding purposes; and of starch, from which starch products are made both for laundry use and as an article of food. Breeding of maize has therefore been carried on, mainly through selection, in order to establish varieties with a higher fat content, others with a larger proportion of protein, and still others with a high starch content. Since, however, the percentage of starch is inversely proportional to that of the fat or protein, it is only necessary to breed for a low oil or protein content in order to obtain a high starch content, and the problem of breeding is thus reduced to two aims. Efforts have also been made to select varieties best suited to different sections. Pioneer work along these lines has been done by the Illinois Agricultural Experiment Station.

There has thus gone on a continuous process of experimentation, selection, and adaptation. It may safely be asserted that the greatest contribution in corn production during the past twenty-five years has been the more scientific selection of seed corn and the determination of standards. While it has been found difficult in practice to fix standards, continued seed selection has gradually developed certain varieties which seem to owe their superiority to transmissible qualities rather than to transient environmental effects. It is this continued selection which has brought Reid's Yellow Dent, to name only one variety, to its present state of perfection.

Along with changes to make a particular variety of corn suit the commercial demands of man or the conditions of climate there have also been efforts to increase the yield of corn.

Planting maize. — The preparation of the seedbed is not essentially different from that in the case of wheat, though subsoiling is found advantageous in heavy soils in the case of corn. There are three methods of planting the seed: (1) it may be " surface " planted in rows one to three inches below the surface; (2) it may be planted at the bottom of a shallow furrow, made by a furrow opener; (3) it may be planted deep at the bottom of a furrow made by a lister, which is essentially a double-moldboard plow throwing a slice each way. In the last case the land is not plowed beforehand.

Surface planting is the method in common use in all states east of the Missouri River, where rainfall is plentiful or where the land is heavy. The lister is used generally where the rainfall is low and the land high. Where the corn is grown for forage it is frequently sown broadcast or drilled thick. In the case of wheat, drilling in rows is all but universal, but corn is often planted in hills. On the smaller and more uneven farms of the North Atlantic states the wheat drill is frequently used for planting maize, but in the North Central and Southern states, where the farms are larger and more level, it is found more economical to plant in hills. The only rule seems to be that the rows or hills must be far enough apart to permit of intercultural tillage, which prevents the growth of weeds and stirs the soil. An important corn planting machine is the " check rower," which allows the planting of the crop in rows running in two directions, thus permitting cross cultivation.

It has been found by experiment that frequent shallow cultivation, from one to two inches deep, increases the yield by killing the weeds and conserving the moisture. Thus, at the New Hampshire Experiment Station in 1900 a yield of 17.1 bushels per acre was obtained where the land was not cultivated after planting and the weeds were permitted to grow, but a yield of 80.6 bushels when shallow cultivation was given fourteen times.[9] Since this is so important, a great variety of ingenious implements have been developed especially adapted to the tillage of corn.

Harvesting maize. — No such profound change has been made in the harvesting of maize as has occurred in the harvesting of wheat and other small grains. The greater part of the maize crop in the United States is still husked by hand from the standing plant; machinery does not play the important part in the harvesting of corn as it does in that of wheat.

It was the custom in colonial New England to harvest the tops of the stalks above the ear for fodder while they were still immature, the ears being later broken off and stored in barns to be husked during the winter. When the North Central and Western states were opened up there was no demand for the stover for cattle, and the practice became general of harvesting only the ears. In the South, however, the custom of " topping " and " stripping " the leaves has been quite common. Corn stalks are usually not harvested, but stand in the fields until they are broken down and plowed under the following spring, though the farm live stock is ordinarily turned into the fields during the winter months to eat what they will of the leaves and husks. When, however, the corn is grown for silage or fodder, then the entire plant is harvested.

In the corn belt states, on probably nine-tenths of the area, only the ears are harvested. It is customary to husk the ears from the standing corn, that is to strip the husks off the ears, and to throw the latter into a wagon. A husker, equipped with a peg or hook in the palm of his hand to assist in tearing off the husks, can husk from 60 to 100 or more bushels of corn a day.

If the corn is cut, this may be done by hand knives or hooks, or by horse-drawn cutters; in the latter case the operator gathers the stalks into bundles as they are cut. Beginning with about 1895 corn binders were introduced and have become steadily more popular; these bind the corn in bundles of convenient size, and drop them in piles of six to eight bundles to be shocked later. After the corn is cut it is gathered in bundles, as just described, and these bundles are set up on end into a great stack, known as a shock, which is tied securely around the top. It is usual to leave the corn in shocks for one to three months to cure the fodder. After the plant has become thoroughly cured, the shocks are generally husked by hand in the field, the ear corn being conveyed to the crib and the stover is again tied in bundles and hauled to the barn or shocked again in the field.

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[9] See also the results of Illinois experiments. Agr. Exp. Sta. Bul. 257.

The most laborious task connected with harvesting corn is husking, and numerous attempts have been made to invent a machine to do this work. The husker and shredder, now in general use, eliminates the labor of husking and at the same time prepares the stalks for feeding. As in the case of wheat threshing, itinerant machines frequently go from farm to farm husking by the day or at a fixed price per bushel. Attempts have also been made to devise mechanical corn pickers to operate in the field, and with considerable success, but such machines are practical only in large fields and under good conditions.

Storing. — The ears are usually stored in rat-proof cribs, holding from 500 to 5000 bushels, which are slotted for ventilation. Corn may be kept in such receptacles for a long time without material loss.

The chief use of the maize crop is as food for domestic animals, and it is in the storage of fodder that the greatest change has come within the past 30 or 40 years. If the corn is grown for silage it is the practice to cut the unripened plant into small pieces by a feed cutter and to put these into a huge receptacle called a silo. The modern silo is from 24 to 40 feet deep, has air-tight bottom and sides, and is filled from the top. Silage is relished by stock and its storage fits well into a scheme of economical farm management.

Shelling. — Corn is generally marketed as shelled corn and is seldom shipped in the ear. Consequently the last step in the production of corn for the market is shelling. In colonial days this was done by rasping an ear across the edge of a frying pan or shovel, but to-day it is done by power shellers which handle 200 to 400 bushels per hour. The shelled maize is then handled like wheat, being hauled to a local elevator from which it is loaded onto cars and shipped to market. At this point it passes out of the farmers' hands and becomes a commercial product.

Conclusions as to the growing of maize. — The growing of maize contrasts strongly with that of wheat at several points. Its cultivation is more intensive, it is grown almost entirely for domestic consumption, and it is used largely for the feeding of stock; that is to say, its consumption by man is largely indirect. Moreover, hand methods have persisted in many of the operations connected with the production of maize, in striking contrast with the general use of machinery in all stages of wheat production. Largely responsible for this, of course, is the character and habit of growth of the plant. While its production has been commercialized, that is to say it is grown for the market and not for family consumption, it has not been industrialized by the application of capitalistic methods on a large scale. On the other hand it resembles wheat in the limited division of labor and specialization involved in its production. It is a true farm crop in which agricultural methods have not yet completely yielded to industrial practices.

SUGGESTIVE QUESTIONS

1. Rye bread is probably sold at the local bakery. Find out if the steady customers for this are persons from Northern Europe.
2. Why don't we eat more rice in this country?
3. The United States exports rice to Japan. Account for this.
4. Why should people with a higher standard of living prefer wheat bread?
5. Enumerate as many different food products as you can which are made of wheat.
6. What is the difference between graham flour and whole wheat flour?
7. Bring some grains of wheat to class and see if you can determine their classification.
8. Distinguish between hard wheat and soft wheat. To what particular uses is each adapted?
9. Who was Luther Burbank and what did he do?
10. Get illustrations of the effect upon crop yield of non-rotation, or non-fertilization.
11. If you live in a wheat growing district, report how seeding is done on a farm with which you are familiar.
12. How is harvesting done? Threshing?
13. Tell how the Indians grew corn, and how they prepared it for consumption.
14. Is a climate, which is favorable to growing corn, pleasant for human beings?
15. If you live in the corn belt, tell how many times it is customary in your district to cultivate.
16. Describe the methods of harvesting corn in your home; of husking.

17. What is done with most of the corn grown in your vicinity?
18. Does the corn growing industry compete with the sugar cane and sugar beet industries?
19. Why is corn from Argentina favored so much in Europe?

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CHAPTER XXIII

COTTON

The need for clothing. — In a previous chapter (Chap. II) we have seen that the primary wants of man are food, clothing, and shelter. Clothing to-day not only meets an essential need, but it may also be regarded as an index of civilization. Primitive peoples still clothe themselves in skins and furs or in garments made of plaited leaves and bark fibers, but civilized man uses woven cloth. The materials for cloth are derived from all three kingdoms, and the most important ones may be classified as follows:

1. Vegetable fibers
   - Cotton
   - Flax
   - Hemp
   - Jute
   - Ramie or China grass
2. Animal fibers
   - Wool
   - Mohair
   - Alpaca
   - Camel hair
   - Silk
3. Mineral fibers
   - Asbestos
   - Gold, silver and other wire
   - Glass

All of these materials have at one time or another been used in the manufacture of clothing, but silk, flax, and wool were the most important in Europe and America until the end of the eighteenth century. To-day cotton is the world's greatest fiber crop, and furnishes the clothing worn by most of the human race who are clothed, as well as materials for many other products.

Importance of cotton. — The extent to which cotton serves your every-day wants may be gaged by noting the varied uses to which it is put. Clad in cotton garments in the morning you step out of bed, in which you have slept between cotton sheets, onto a cotton rug. You slip your feet into a pair of cotton slippers and raise a cotton window shade to let in the light. In your bath you use a cotton washcloth and soap made partly from cottonseed, and dry yourself with a cotton bath towel. Your underwear, hose, shirt, collar and probably your outer garments, in part at least, are of cotton. Your new magazine and the books you read are printed on paper into which cotton enters. Cottonseed products may enter in various ways into the food you eat, as cottolene, cottonseed oil, oleomargarine, etc. The automobile in which you ride has cotton in its tires. If you cut your finger you would need cotton gauze to bandage it. And such a list by no means exhausts the every-day uses to which cotton is put. It would be practically impossible to dispense with it, for upon cotton and iron, more than upon any other substances, is built modern industry.

Increased demand for cotton. — Not merely is cotton important, but the demand for it and for its products has been growing steadily for one hundred and fifty years. There is every reason to believe, moreover, that the consumption of cotton will expand in the future quite as rapidly as it has in the past. For this belief Professor Todd gives the following reasons[1]:

In the first place the spread of civilization throughout the world has led to a demand for more and better clothing. " It is estimated," says the United States Department of Agriculture, " that of the world's population of 1,500,000,000, about 500,000,000 regularly wear clothes, about 750,000,000 are partially clothed, and 250,000,000 habitually go almost naked, and that to clothe the entire population of the world would require 42,000,000 bales[2] of 500 pounds each. It therefore seems more than likely that the cotton industry will go on expanding until the whole of the inhabited earth is clothed with the products of its looms."

In the second place, cotton is being increasingly used as a substitute for other raw materials. Table and bed " linen," shirts, handkerchiefs, and collars, " flannels," tweeds, " silk " thread and fabrics of every sort made of mercerized cotton, have been manufactured from cotton, not merely as imitations, but as thoroughly satisfactory substitutes for linen, wool, and silk goods.

In the third place, numerous new uses for cotton have been discovered in recent years, and the number is steadily growing. Among these may be mentioned gun cotton, webbing for automobile tires, typewriter ribbons, airplane wings, covering for electric wires, and many others.

Improvement in the quality of cotton goods and reduction in their price have made an appeal to new classes of buyers and have developed demands which are apparently insatiable. The history of a century seems to show that demand for cotton and its products runs constantly ahead of the supply and is capable of absorbing any addition to the supply.

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[1] J. A. Todd, *The World's Cotton Crops,* p. 3.

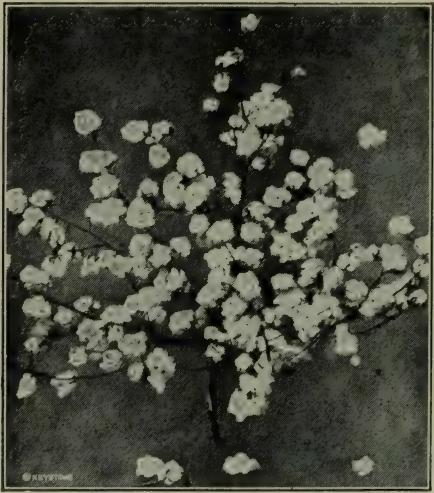
[2] The world production for 1924 was about 24,000,000 bales.

History of cotton. — The use of cotton antedates the beginning of recorded history, and reaches so far back into the past that it has not been found possible to determine definitely its original home. The East Indies was probably the place where it was first used, but cotton in its wild state has been found in practically every country between the 37th degree of latitude north and south of the equator except — curiously enough — the present cotton belt of the United States. And yet, in spite of its antiquity and its early use in India, its cultivation is of comparatively recent date in the chief cotton producing countries of to-day. It seems not to have been fully introduced into China until about 1000 A.D.; it was first cultivated in Egypt about the thirteenth or fourteenth century; and the first record of its being grown as a fiber in the United States was in 1621. The real impetus to its production in this country came, first, with the introduction of Sea Island cotton in 1786, and, second, with the invention in 1793 of Whitney's cotton gin, which made possible the profitable production of short staple or Upland cotton. Cotton was practically unknown to the nations of Europe only a little more than two hundred years ago, and its general use as a textile material dates back not much over one hundred years.

What is cotton? — Raw cotton is the fluff or fiber which surrounds the seeds of the cotton plant. Its primary function was, doubtless, in the economy of the plant, to act as a protective covering for the seed and possibly to promote the distribution of the seed by acting as a parachute, as is done in the related milkweed. The cotton fiber is described by Monie as " a flattened hollow ribbon or collapsed cylindric tube twisted several times throughout its length, and with the outer edges corrugated and indented somewhat similar to a saw."

These characteristics differentiate cotton from other textile fibers and give to cotton its most valuable qualities. This is best illustrated by an example. If you will take two samples of cotton fiber and two of, say, flax and attempt to twist them into a strand or thread with your forefinger and thumb, you will find that the flax fibers will uncoil themselves while the cotton retains almost exactly the position into which it was twisted. A familiar example is the twisting of the end of a thread into a point in order to thread a needle. The reason for this is that the natural twist of the cotton fiber tends to make it entwine itself round its neighbor, and its flatness and serrated edges hold it in place. Many of the fibers allied to cotton, such as thistle-down, milkweed silk, etc., have no twist and no rugosity, and consequently cannot be used for spinning although their high luster has led to attempts to utilize them.

The cotton plant varies in appearance and growing characteristics in different countries, but in general may be described as a shrub-like plant, growing in the United States about 2 to 4 feet high, with more or less wide-spreading branches at the bottom and tapering to a point at the top. When closely planted the branching is restricted. The leaves are large and divided into lobes, that of the American Upland resembling an ivy leaf. The flower differs in color in different species, that of American Upland being creamy; it becomes darker and redder the second day, and falls to the ground the third or fourth day, leaving a tiny boll developed in the calyx. This boll develops and enlarges until maturity, when it is similar in shape and size to a hen's egg.



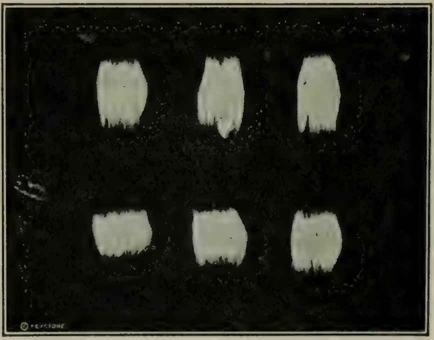
A Cotton Plant at its Best

The value of a cotton plant depends upon the number of bolls which grow to maturity. The amount of cotton to a plant seems determined more by its structure than by its height, and both are affected by the soil, the climate, and the skill in cultivation.

The boll is divided into three to five compartments, each containing seven to nine seeds, to which the lint or cotton is attached. In this respect, too, there is a great difference among the various species. The seeds of the Sea Island and Egyptian cotton are black or brown, and the lint is easily separated from the seed. These seeds are known as " black " or " clean." In the American Upland and Indian varieties, on the other hand, there are two kinds of lint, one — the actual cotton — being about an inch in length and coming away fairly easily from the seed in the gin. The other is a short fuzz, which adheres closely to the seed and can only be partially removed; this is known as " linters." The seeds of these varieties are known as " white " or " fuzzy."

When the boll reaches maturity the doors of the compartments open, the lint and seed expand and protrude from the boll, and there is presented the typical picture of the cotton field, white with its open bolls and ready for the picking.

Classification of cotton. — There are many classifications of cotton, some according to their botanical characteristics, others according to the varieties, and still others according to the grade or qualities. Thus on the New York Cotton Exchange some thirty grades are distinguished all based upon " middling " Upland cotton. The most convenient classification, however, is according to the length of the fiber. This gives three main groups: (1) Long staple, which is over 1¼ inches; this comprises Sea Island and Egyptian. (2) Medium, which is between ¾ and 1¼ inches; this is represented by American Upland. (3) Short or all under ¾ inch; in this group fall most Indian varieties. Cotton less than ⅜ inch has no value except as cotton waste.



Varying Lengths of Cotton Staple

The cotton staple varies in length from an average of about .93 inches for Upland cotton to 1.61 inches for Sea Island cotton. Length of staple is one of the qualities sought by breeding and cultivation.

Length of staple, however, is not the only criterion, but other important characteristics are also taken into account. Among these are ripeness or maturity, uniformity of length, fineness, strength, moisture, etc. These are all sought for in cotton growing.

Improvement and breeding. — The factors which exert the greatest influence upon the cotton plant are (1) the seed, (2) the climate, (3) the soil, and (4) the mode of cultivation. In the present paragraph will be considered only the improvement of the plant through seed selection; subsequent paragraphs will deal with the other factors.

The laws at work in cotton seed production are the same as those already studied in animal breeding and in the improvement of wheat and maize, namely those of heredity and variation. Differences in the character of seed produced under exactly the same conditions of soil, climate, and cultivation are constantly appearing. The problem in seed improvement is to select those specimens which exhibit the most desirable qualities and make them the parents of the next generation. In the United States it is now the accepted practice among the larger and more enlightened cotton growers to select the seed systematically and to grow special seed for planting each year, but the average small grower pays very little attention to the quality of the seed he uses and makes no effort to improve it. The method of improvement may be illustrated by a couple of examples cited by Watt (p. 282).

Sea Island cotton was greatly improved on James Island by systematic seed selection. Each year the best plants in a field were marked and the cotton from them tested as to quantity, length, fineness, strength, softness, and other qualities. The seed from the best plants was next season planted by itself and about 500 plants obtained; these were again subjected to observation and the undesirable specimens rejected. The seed from the best plants was again sown separately, this time being sufficient for about five acres. In the fourth year the seed from these five acres was used for general planting. By keeping a series of these breeding plats in operation a constant supply of selected seed was always assured, and the high quality of the cotton was maintained. A simpler and easier method, which is frequently followed, is merely to select the best bolls from the best plants each year, and use the seed from these for general planting.

The other example illustrates the success of such methods. A destructive disease known as " Cotton Wilt " could not be overcome by any known method of treatment, so an effort was made to produce a disease resistant variety. It was noticed that even in the worst infected districts a few plants remained healthy. The most satisfactory of these healthy plants was marked and the next year its seed was sown in special rows in a badly infected plot. Again a rigid selection of the most healthy plants was made and in a few years several races of wilt-resistant plants were developed.

The cotton breeder, like the animal breeder, has an ideal toward which he is working. On the whole, those qualities which count for most in the sale of the commercial product must be given first consideration. These involve the following: an abundance of bolls, bolls of large size, large yield of lint, high percentage of lint as compared with seed, and fiber of good length, fineness, strength, and uniformity. The average yield of cotton in the United States to-day is less than 200 pounds of lint to the acre. Systematic and careful seed selection alone might raise it to the average Egyptian production of about 450 pounds to the acre, especially since the other factors of improvement are, on the whole, more favorable in the United States.

Climate and soil in the United States. — The cotton belt in the United States stretches from the Atlantic Ocean to western Texas; its northern limit is marked roughly by a line drawn from Norfolk, Virginia, to Cairo, Illinois, and thence to Cuates, New Mexico. The area of this belt is about 700,000 square miles or 450,000,000 acres, but of this land less than one-tenth is actually in use for growing cotton (40,000,000 acres in 1924).

Ideal conditions for the successful cultivation of cotton are a soil of fine sandy loam, a relatively high temperature, a long growing season, a moderate and well-distributed rainfall throughout the growing season, a small amount of rain at maturing time, and a great deal of sunshine. These conditions are found in the American cotton belt to a greater degree than in any other considerable area in the world. If the territory in other parts of the world between the latitudes of 37° north and south be examined on the map, it will be noticed that in most of this territory one or another of the conditions just enumerated are lacking. The cotton belt of the United States possesses, therefore, a certain monopoly of location, which has made the cotton manufacturing countries of the world measurably dependent upon it. Over half of the annual world supply of cotton comes from this area.

Kinds of cotton. — There are two main kinds of cotton produced in the United States — Sea Island and Upland. Although small in quantity (less than one per cent of the total), the Sea Island cotton is very important because of the length of its fiber and its silkiness. It is chiefly used in making fine thread for delicate muslins and fine lace, or where great strength is needed as in automobile cord tires. Sea Island cotton is grown, as the name indicates, on islands off the shore of the Carolinas and in the West Indies; a slightly inferior grade is grown on the mainland in Georgia and Florida.

Upland cotton constitutes the bulk of the crop in the United States. A few years ago the terms short-staple and Upland were interchangeable, but the great demand for long staple has led to the successful development of new varieties with a staple length of one and one-eighth inches and more. This long-staple Upland is best grown in the Mississippi delta, the large triangular area lying between the Mississippi and Yazoo rivers in the states of Mississippi, Tennessee, and Arkansas. A new variety of long-staple Egyptian cotton is also being produced in two irrigated districts, one in the Salt River Valley in Arizona and the other in the Imperial Valley of California. The great bulk of the crop, however, is still the short-staple Upland cotton.

Preparation of the land. — Throughout the greater part of the cotton belt the one-crop system has long been practiced, according to which cotton is grown continuously with little or no rotation of crops. Such a system inevitably uses up the fertility of the soil; and the situation has been rendered even worse since the sale of the cotton seed from the farm, for now not much of it is returned to the soil as a fertilizer. The problem of the best treatment of the soil resolves itself therefore into a question as to the methods best adapted to help the soil provide the necessary plant food for the growing cotton plant.

Fourteen chemical elements are demanded by the cotton plant, but of these only three need to be provided in considerable quantities; namely, nitrogen, phosphorus, and potassium. Of these nitrogen is the most expensive element of plant food to buy, and should therefore be produced as far as possible on the farm. The two best methods for the introduction of nitrogen into the soil are by means of farm manures and legumes. In mixed farming cattle are raised on the crops and their manure returns to the soil the nitrogen extracted. If cattle were generally kept throughout the cotton belt and fed on cotton seed meal, the problem might be solved in this way. Since this is seldom done it becomes even more necessary to follow the second method of a rotation of crops in which legumes like cowpeas and clover shall be utilized to fix in the soil the abundant atmospheric nitrogen.

Phosphorus is the chief element demanded by most cotton soils, but since this is a mineral substance any deficiency must be supplied from outside sources. Fortunately an abundant supply of phosphate rock has been discovered in the Carolinas, Florida, Georgia, and Tennessee.

Potassium seems to be less urgently demanded by the cotton plant than either of the other two elements, which is fortunate, for during the war the chief source of supply, the potash mines of Germany, was closed to us, and has not since yielded the prewar amounts.

Fertilizing the soil and restoring its exhausted elements is, however, only one step in the process of preparing the land for the reception of the seed. Another hardly less important one is that of preparing the seedbed. Good plowing does much to restore fertility by letting air and moisture into the soil and helping to make plant food available for the growing roots. Deep fall plowing should be practiced on all but the richest soils, as this separates the particles of earth, permits the frost to penetrate more deeply and the air and moisture to circulate freely, and stores up the winter rains for use in the spring and early summer. In the spring the land should be rebroken some three or four weeks before planting, so as to give sufficient time for the beds to become firm. This process of pulverization, begun in the fall with the plow, should be completed in the spring with the harrow, which may be followed by a wooden drag or roller to crush the clods and level the seedbed. Just before planting, the surface of the bed should be thoroughly pulverized and freshened. The land has now been made an efficient instrument for the part it is to play in transforming the inert seed into bolls of fluffy cotton.

Planting. — When the danger from frost is past and the ground becomes warm enough to favor germination, and is properly prepared, seeding may begin. This time varies from March 1 in southern Texas to May 15 in the northern part of the cotton belt. Cotton is always planted in rows so as to permit cultivation during the growing season and easy access to the plants during the picking season. The general rule for spacing is that the distance between the rows should be slightly more than the average height of the plant in that locality. In practice, this will give a normal distance of about four feet, though the extremes will vary from three to five feet. The distance between plants in the same row will vary from 12 to 24 inches in order to give room for the plant.

Cotton seed is usually planted by a cotton planter which drops the seed in a continuous drill, at a depth of about one inch. This is a rather wasteful method, for about twice as many plants start growth as can find room to mature, and the excess have later to be thinned out. Some of the more recent planters consequently have an adjustment for dropping the seed in hills instead of in a continuous drill.

Cultivation. — The purposes in cultivating during the growth of the plant are to kill weeds, provide a mulch so as to conserve the moisture in the soil, and release plant food. Cultivation may begin as soon as the seeds are planted by running once or twice across the rows with a section harrow. When the cotton is up to a stand, a harrow or weeder may be run diagonally across the rows in order to kill the grass and weeds, and a week later diagonally in the opposite direction. This has killed some of the young plants, but they are still too thick, and the next step is " chopping " or thinning. This is done with a hoe, though a better planter and more generous use of the harrow or weeder may eventually make this antiquated implement unnecessary.

When plants are three or four inches in height, cultivation with a cultivator may begin, and should be continued every week or ten days until the plants have reached maturity. This later cultivation must be shallow, not over an inch or two, so as not to destroy the branching lateral roots which by now have stretched out in every direction just beneath the surface. Cultivation is designed to assist the plant in its struggle toward maturity. It therefore opens the soil in order that the roots may enter; it increases the amount of plant food; it kills the weeds which are competing for the food and moisture; it blankets in the moisture and prevents its evaporation. The work must therefore be carefully and effectively performed. On some of the poorer farms, where inefficient tools are matched by ignorant practices, the one-horse plow is used not merely for plowing — which it does not do deeply enough — but also for cultivating, which it does too deeply, and thus injures many of the growing plants. Successful cotton growing is hampered in the South by ignorant and wasteful methods, and by insufficient capital investment; on many a small cotton farm a mule, a plow, and a hoe represent the farmer's equipment, and tradition his stock of knowledge.

Harvesting cotton: picking. — There are three steps in harvesting cotton — picking, ginning, and baling. Picking begins as soon as enough bolls open to justify going over the field. The date of beginning picking varies from the middle of July in southern Texas to the end of September in the northern districts, though it goes on generally throughout the winter owing to the lack of sufficient labor to pick it as soon as ripe. One man can easily cultivate from twenty to thirty acres of cotton, but it requires four or five good pickers to gather the cotton from such an area fast enough to keep it from being damaged by the weather; or, to put it another way, it would take practically all winter for one man to pick a crop which he can raise. This long harvesting period is an important advantage in cotton production as compared with wheat, hay, tobacco, or even corn, in which cases inevitable loss follows if the harvesting is not promptly done. There is, of course, deterioration in the case of cotton left too long in the field, but the crop is not lost.

Picking is done by hand, just as it was in India a thousand years ago. The pickers creep along between the rows, bending down to gather the cotton from the lower bolls, plucking the cotton from the three or four ripe bolls on each plant, and thrusting it into a long bag slung over the back by a band round the neck. When these are full they are emptied in piles at the end of the rows, and the piles are weighed to ascertain the picker's wage. After weighing, the cotton is hauled to the barn or other place of storage.

Of all the operations in the production of cotton, picking is the most expensive. An experienced picker will pick from 150 to 200 pounds per day, but the average is much less. Before the World War, the price for picking cotton ranged from thirty-five cents to a dollar per hundred pounds of seed cotton, which would make the cost of picking a ginned bale of 500 pounds of cotton lint vary from $5.25 to $15. The high cost of picking and the limitation on production from an insufficient supply of labor have led to repeated attempts to produce a mechanical picker. Many machines have been patented, but none has been entirely satisfactory. There is no reason to doubt, however, that inventive genius will eventually produce a practical mechanical picker, just as it has developed mechanical harvesting machinery for other crops. With a successful machine for picking the cotton, acreage could be greatly increased and cotton production be industrialized in the same way that wheat and maize have been.

ELECTRIC COTTON PICKER

Many mechanical pickers have been tried, but none has been very successful as yet. The illustration shows a recently invented electric cotton-picker, in which revolving brushes pull the cotton clean from the bolls at the rate of 60 per minute, and the suction then carries the cotton through flexible tubes to the bag on the tractor.

Ginning. — The second process in harvesting cotton is ginning, or the separation of the lint from the seed. When cotton is gathered from the bolls it is known as seed cotton, for it contains both seed and cotton lint. To prepare cotton for the market it is necessary to separate these two products. At one time this was done by hand, and the cleaning of one pound of lint from the seed was a day's work; since the invention of Whitney's cotton gin in 1793, however, this process has been performed by machinery. The modern gin in the United States separates on the average about 750,000 pounds of seed cotton a year, or slightly over 500 bales of ginned cotton. Some years ago, nearly every plantation had its own gin, but this was found to be very expensive; next portable gins, like traveling threshing outfits, were tried, but scarcity of fuel, poor roads, and other unfavorable factors showed these to be impracticable. To-day, therefore, most cotton is hauled to a large, centrally located, stationary gin, which is generally operated by steam power.

To such a gin the farmer's cotton is hauled in an open box wagon, from which it is sucked up by a pneumatic suction pipe, which cleans up every particle in a very short time. The cotton is then carried by the suction pipe into a series of hoppers above the gin stands, from which it falls, sometimes through beaters or fanners for cleaning purposes, into the gins below. A typical gin consists of about seventy circular saws running at about 400 revolutions per minute. The upper edges of the saws pass through slots in a frame, through which they pull the lint, while the seed falls back into a trough along which it is carried by a traveling screw or by suction into a box outside. The lint is drawn, still by suction, into a closed lint-flue which runs along behind all the stands and leads into the condenser, where the cotton is formed into a loose " lap " and falls in folds into the press-box.[3]

Sea Island cotton, from which the seed is more easily separated, is ginned by a roller gin. This is done to prevent cutting the long and valuable fiber, which is frequently done by the saw gin, especially if it is run at high speed.

Baling. — The cotton farmer usually sells his cotton in the bale, so that baling may be considered as the final step in harvesting, preparatory to marketing. When the cotton lint falls into the press-box, as described above, then the process of baling begins. Two pieces of jute are first put into the press, to serve as a cover. As the box fills, the cotton is lightly pressed down about every half minute by a mechanical tamper or packer. Six iron bands are put around the bale in the press, and the flat bale is handed over to the farmer.

This process and the subsequent treatment of the baled cotton have been made the subject of very severe criticism. The bales are made in various sizes, differing greatly as to weight. They are poorly covered, so that the covering is easily torn, allowing the lint to drop out and become dirty, a probability which is greatly increased by the practice of " sampling " or slashing a hole in the side of the bale and pulling out a liberal sample of cotton. The farmer frequently leaves his baled cotton out in the open, exposed to rain and dust, though the building of storage warehouses is gradually providing facilities for its care before going to market. The American cotton bale has been described as " the clumsiest, dirtiest, most expensive, and most wasteful package in which cotton, or in fact any commodity of like value, is anywhere put up."

If the cotton is to be exported or shipped to a distant market, the farmer's bale is taken to the nearest compress. Here it is unbanded and compressed to about half its former size, so that it will occupy less space in freight car or ship. Patches of bagging are put over the sample holes and eight bands replace the original six. The bale is now in better shape for a distant journey, but it nevertheless usually reaches its destination in a very tattered and bedraggled condition, unparalleled, it is said, by any cotton-growing country in the world except Mexico.

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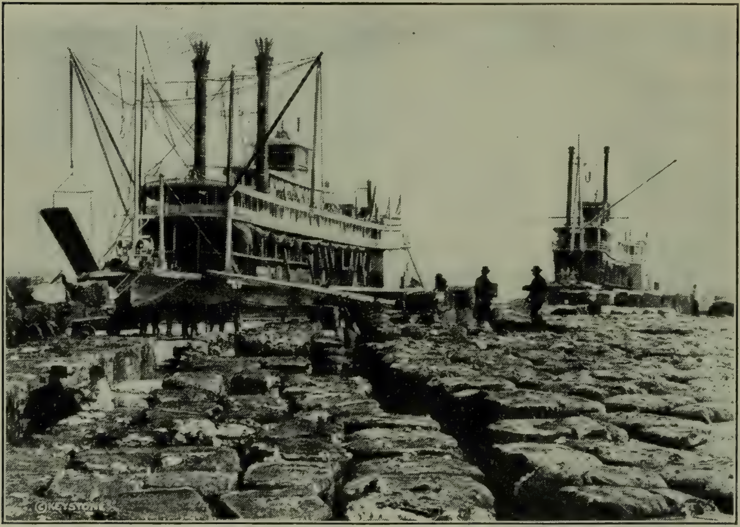
[3] J. A. Todd, *The World's Cotton Crops,* p. 119.

Conclusion. — Even such a brief survey as has been given of the cotton growing industry inevitably leads to the conclusion that the methods and processes at almost every stage of production are antiquated, ineffective, and wasteful. And this is true, not merely of the United States, but also of India, China, Egypt, Africa, and South America. It is grown for the most part by labor which is poorly trained, ignorant, and without sufficient capital, as the mere enumeration of countries indicates. Such cultivators are incapable or unwilling to avail themselves of the best practices of which indeed they generally remain ignorant; they are unable by reason of their poverty to obtain efficient tools or machines. The scattered and dispersed nature of the industry makes it difficult if not impossible to raise the general level, though county advisers and coöperative associations are aiding the more enlightened individuals to improve their methods.



Loading Cotton at New Orleans

The usual condition of the cotton bales, insufficiently wrapped and broken open, is shown in this illustration. This results in serious loss to American cotton growers.

Thus far, too, cotton growing has remained largely a hand crop, and labor-saving machinery has found but limited use. Partly this is due to ignorance and poverty, as in the work of plowing and cultivation, but partly it is due to the nature of the plant, as in picking. But even where machinery can be economically used, as in ginning and baling, the results are often unsatisfactory. It is clear that cotton growing has remained a small-scale farm enterprise, but little affected by the processes of industrialization, specialization, division of labor, and large use of machinery which characterize wheat production. The lines along which improvement may be expected have been indicated, but changes will probably come only slowly.

SUGGESTIVE QUESTIONS

1. Aside from clothing, have you made use this day of any product into which cotton entered?

2. Does the cotton fiber enter into the manufacture of clothing under any other name?

3. Get a cotton boll and bring it to class with you.

4. What are the different types of cotton? How can they be distinguished?

5. Try the experiment suggested on page 325 of twisting various fibers into a thread.

6. The Cotton Growing Association of Great Britain is making efforts to promote the growing of cotton in Africa and the Near East. Is it likely that these districts will supplant the cotton belt of the United States?

7. If you live in the cotton belt, describe the methods of planting which prevail in your district.

8. Is the land in your district " run down "? Why or why not?

9. Which plant food does cotton receive from the soil in largest amounts?

10. What is the effect of the different plant foods in the development of the cotton plant?

11. What methods are used for picking cotton near your home? Have you ever seen a mechanical picker at work?

12. Are there any economic reasons for the particular methods of cultivation and harvesting which are employed?

13. Foreign cotton mill owners complain that American cotton is the worst baled which they receive from any part of the world. Why is this?

14. Describe the manner in which the boll-weevil injures the cotton boll.

15. The boll-weevil does but little damage along the extreme northern and western edges of the cotton belt. Account for this.

16. Cotton has been called a cheap labor product. Criticize this statement.

17. Find out the trend in the yield of cotton per acre in the United States during the past two decades and account for the direction of this trend.

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CHAPTER XXIV

TOBACCO

History of tobacco. — Like maize, tobacco is a contribution of the New World to the Old. Although it had been used by the Indians for probably untold centuries before the advent of the white man, its discovery by Europeans was coincident with that of America by Columbus in 1492. Columbus and his successors carried the strange story of its use by the Indians, together with seeds and specimens of the plant, back to Spain. They gave to it the name " tobago," which was the Indian name for the pipe in which it was smoked; later this was corrupted into tobacco. Jean Nicot, whose name is immortalized in nicotine, introduced it into France in 1560; and Sir John Hawkins probably was the first who, in 1565, took it to England. Dutch and English traders carried the seed to Turkey and Syria, and Spanish vessels took it westward to the Philippines, and thence it spread to China and Japan. Thus, within two centuries after the discovery of America, tobacco had spread to nearly every country in which it could be profitably raised. Next to the most common grains, probably no plant is to-day so widely or generally cultivated as is tobacco.

Within the territory now included in the United States, tobacco growing began in Virginia practically as soon as the first settlements were made; John Rolfe, perhaps better known as the husband of Pocahontas, is believed to have been the first white man to cultivate it. Tobacco soon became an important crop. Repeated attempts were made by legislation during the colonial period, both in England and the colonies, to regulate the production, trade and consumption of tobacco. With better knowledge of the plant and of the conditions of cultivation, its production spread from Virginia into other sections, until to-day it is grown in several states. The larger part of the crop is raised in the following states, in order of importance, (1924): Kentucky, North Carolina, Virginia, Tennessee, Pennsylvania, South Carolina, Connecticut, Wisconsin, Georgia, and Ohio. Over half is produced in the first two states, and two-thirds in the first three.

Consumption and use. — Tobacco is used for smoking in the form of cigars, cigarettes, and pipe tobacco, and for chewing and snuff. The distribution of the home manufactured products among these different uses was as follows for the five-year period, 1917–21: cigars, 25%; cigarettes, 26%; smoking tobacco, 27%; chewing tobacco, 17%; snuff and other products, 5%.

The other products referred to are made out of the refuse and waste and comprise such items as sheepwash, plant fumigators, etc.

The consumption of tobacco in this country has increased steadily since 1863, when it was 1.6 pounds per capita, to the present time; the average annual consumption for the five-year period 1917–21 was 8.5 pounds per capita of the entire population. The consumption in the United States is higher than in any other country and has increased more rapidly. Most of the tobacco exported goes to Great Britain.

What is tobacco? — Tobacco belongs in the nightshade family (*solanaceae*), which comprises such plants, mostly American, as red pepper, white potato, tomato, and egg plant. The genus *Nicotiana* embraces some fifty or more species, of which one, *Nicotiana tabacum,* supplies nearly all the tobacco of commerce. The following quotation gives a botanical description. [1]

"The tobacco plant grows from two to nine feet high, with wide-spreading leaves, ovate, oblong or lanceolate in form. The leaves are alternately attached to the stalk spirally, so that the ninth leaf overhangs the first, and the tenth leaf the second. The distance between the leaves, on the stalk, is about two inches, in ordinary varieties. The flowers are in large clusters, with corollas of rose color, or white tinged with pink, and about two inches long, funnel-shaped, with inflated throats. Tobacco is a rank, acrid narcotic, viscidly pubescent, leaves and stalk covered with soft downy hair. The seed pods have two valves."

The plants ripen about three months after being planted, becoming a yellowish-green color, the leaves sometimes being mottled with yellowish spots. They also become gummy, and the viscid, resinous exudation from the leaves smears everything it touches. Tobacco raising is therefore very dirty work.

The green leaf contains a large percentage of complex organic bodies, but during the process of ripening and curing it undergoes certain chemical changes by which most of these are removed. The dry leaf consists largely of mineral constituents which form the characteristic tobacco ash, when the tobacco is smoked. Nicotine, the essential characteristic alkaloid of tobacco, is found in no other plant. It is colorless and liquid at ordinary temperature. It is a narcotic poison, but is never present in large quantities, and is largely consumed and destroyed in the smoke. Tobacco acts both as a sedative and a stimulant, depending upon the individual and the circumstances.

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[1] Killebrew and Myrick, *Tobacco Leaf,* p. 27.

Influence of climate and soil. — The successful raising of tobacco depends on four principal factors: (1) the climate, (2) the nature of the soil, (3) the seed, and (4) the method of cultivation.

Of these *climate* is probably the most important, for this determines the flavor, the fineness of texture and elasticity of the leaf, upon which the value of a tobacco chiefly depends. The climate must be such as to favor rapid growth and must therefore furnish sufficient heat and moisture during the growing period. These conditions seem to be best met in Cuba and the Philippines, in which countries are grown the best tobacco. The longer period of growth in the warm climate of the Southern states in this country, gives time for the storing up in the leaves of oil and waxes and gums, and even of saccharine matter, which make the tobacco of these regions more heavy, sweet, and fragrant than those grown in the North. On the other hand, the tobacco grown in Connecticut, Pennsylvania, or Wisconsin, is more delicate and inodorous.

On the *soil* the plant depends for its food, and for those chemical elements on which depend the burning qualities, the strength, and the color of the tobacco. Certain definite amounts of potash, nitrogen, phosphoric acid, lime, magnesia, iron, and sulphuric acid are necessary to produce a given weight of tobacco. In case any of these substances is deficient in the soil, it must be supplied by suitable fertilizers. Since the period of growth is only about three months, the plant must mature very rapidly, and the supplies of food must be so abundant that the quickly extending roots may find them at every point. Most growers agree that tobacco is a crop demanding a rich soil, but fertilizers must be applied with scientific exactness or an unsatisfactory product will result.

The physical properties of the soil seem to be even more influential in determining the quality of a tobacco than its chemical composition. No other plant requires the soil in such a friable state. A light soil produces the finest and most aromatic smoking tobacco, while a heavy, clayey soil yields a thicker and coarser leaf. Indeed the tobacco even reflects the color of the soil, for the " bright " yellow tobaccos are grown on light colored, porous soils, while dark tobaccos are grown on dark colored soils. These facts are so well understood that the tobacco industry has become highly localized and specialized, and manufacturers look regularly to certain well-defined areas of production for their supply of the various classes and types of leaf required. Each important district produces a tobacco of certain well-known characteristics which make it suitable for special purposes of manufacture, as for cigars or cigarettes, or for export.

Breeding. — The physical qualities of the plant, its structure and form, are derived from the *seed.* So far has the breeding and the development of desirable varieties proceeded that to-day most growers seek to perpetuate, unchanged, the type of tobacco which they have ascertained by experience is best adapted to their district. Scientific breeding for new varieties by cross-fertilization is usually carried on by the Agricultural Experiment Stations. It has been found possible, as in the case of wheat, maize, and cotton, to breed tobacco plants for the development of particular qualities. Thus the width and fineness of the leaf may be increased by crossing two varieties, each of which has one quality highly developed. So readily do varieties mix, however, that if a planter wishes to keep a given variety unmodified, he will not plant another variety on the same farm.

In case a planter is primarily interested in preserving the characteristics of the variety which he is growing, he will select for seed the best and strongest plants. These are not " topped," like the remainder of the crop, but are left standing when the crop is gathered. All suckers are removed, and when the seed pods blacken, they are ripe. The heads are then cut off and they are hung in a dry place to cure. Seed thus selected is sometimes extremely valuable and is handed down from generation to generation as a choice legacy of families of tobacco raisers. These tiny seeds have been called one of the miracles of nature, as the seed from a single plant could produce enough to set 250 acres, if all the seed germinated and all the plants thrived.

Preparation of the land. — Methods of cultivation differ among the various tobacco-growing sections, almost every one of which has its distinctive practices; it is possible, therefore, in the following paragraphs to describe only typical processes. Since a rapid and uninterrupted growth is necessary in order to produce the finest textured leaf, clean and thorough preparation of the soil is essential. Early in the fall from ten to twenty tons per acre of stable manure are plowed under to a depth of about eight inches. In the spring the land is again plowed to a depth of three or four inches, and harrowed, and fertilizers are broadcast with a machine adapted to the purpose. Care must be taken to supply the exact amounts of nitrogen, potash, and phosphoric acid needed by the growing plants as plant food, and of lime, magnesia and other elements to affect the mechanical character of the soil and thereby insure good burning qualities of the tobacco. For this purpose a combination of cotton-seed meal, cotton-hull ash, lime, and land plaster is generally used. Immediately before the young plants are set out, the field should again be harrowed, smoothed and rolled.

The field is then marked out in rows about three feet apart each way, and at the intersections of these rows small hills are made to receive the transplanted plants without danger of their being washed away by heavy rains.

Few crops need such careful preparation of the soil. It is especially desirable to avoid bringing up the subsoil to the surface or turning the humus under. It used to be thought that tobacco was unusually exhaustive of the soil, but it is not more so than other crops if proper rotation and fertilization are observed.

Raising seed. — All this time work is going on in germinating the seed and preparing the seedbed, for the tender tobacco plants must be well started before they can be transplanted to the field.

Although the seedbed is small, averaging about two square yards for each acre of tobacco field, its preparation is important and expensive. It has been estimated that the cost of the seedbed alone is about three per cent of the total cost of tobacco production. The seedbed should be situated in a spot sheltered from the cold northern winds, and with a southern exposure, so that the warm rays of the sun may hasten the growth of the plants and permit their transplanting before the hot weather sets in. Great care must be exercised in selecting the right kind of soil, the best being a rich, friable, black virgin loam, or sandy soil. Over the area selected for the seedbed dry brush and wood are burned and the ashes well raked in, care being taken not to reverse the soil and bring any subsoil to the surface.

Burning the soil has several good effects. It destroys all seeds of weeds and grass; it makes the soil more friable and permeable to the roots of the plant, thereby increasing the area of the feeding ground of the roots; the minute particles of charcoal left after burning make the bed warmer and absorb carbonic acid gas, which is a valuable plant food; and finally, burned clay fixes nitrogen more readily than unburned, and its mineral substances are rendered more soluble and available as food for the plants.

Meanwhile the seed has been prepared for planting. In the North it is customary to sprout the seed before they are planted in order to hasten the growth of the plants, but in the South this is unusual. A heaping tablespoonful of seeds will sow 100 square yards. The seeds are sprinkled over the bed, but are not raked into the soil, as that would cover them too deeply; they are pressed in with a board or by treading with the feet. Firming the soil is essential to success, as the compact surface retains the moisture and assists the growth of the plant.

Care of the seedbed. — The tobacco plant requires almost as much attention during its infancy as does a baby child. The sprouting seed must be protected against cold and insect enemies. This is done in the North by the use of the glass sash, but in the South the beds are usually covered by canvas frames. This keeps the beds moist and warm, it prevents the accumulation of drift leaves or trash, and it keeps out noxious insects. The cover is removed after the plants are up, at first only in the sunny part of the day, but gradually for a longer time until it finally is left off altogether. The plants are thereby " hardened " so that they can withstand the shock of transplanting and make a vigorous growth later. When the plants have developed from four to six leaves and are five to six inches in height, they are ready for transplanting. A knowledge of just when and how to transplant these seedlings is one of the most important acquisitions of a successful tobacco planter, and one most difficult to acquire. It takes about thirty or forty days from the planting of the seed for the plant to grow sufficiently to be transplanted.

Transplanting. — The work of transplanting requires the utmost care. The seedbeds should be thoroughly wetted and the young plants gently pried out to avoid breaking their roots. As the plants are drawn out they are laid down in straight piles, the roots being all kept together. After this they are placed in baskets, or in a wagon, or in a transplanting machine and taken to the field. If the plants are to be set out by hand a dropper takes a basket of plants and drops one on each hill in two rows. He is followed by two setters or planters, each taking a row. The setter makes a hole with a dibble, about four to six inches deep, into which he sets the plant, pressing the earth firmly around it. Showery or damp weather gives the best conditions for this process; if the day is clear the plants should be watered so that the surrounding soil will settle about the roots.

A much more expeditious and satisfactory method of setting tobacco plants is to use a transplanting machine. This not only sets out the plants more rapidly but does it better than can be done by hand. The machine carries a supply of water, and the roots of each plant are thoroughly wet below the surface of the ground, while being set. This insures a better start, and permits the grower to plant at any time, irrespective of the weather, while the machine-set plants mature more evenly and quickly than hand-set plants.

Cultivation. — As soon as the plants start to grow again cultivation begins and continues as long as the size of the plants will permit. The production of a fine crop requires no less than six different cultivations. Constant weeding is required, but as the roots of the tobacco plants grow very rapidly and soon fill up the space between the rows, it is not possible to do more than keep the surface loose and mellow. This is the reason why it is necessary to prepare the soil so carefully in advance. At first cultivation is done by a cultivator, but later, when the roots spread out, the hoe must be used to keep down the weeds. It is during this period too, that the green hornworm and other insect enemies of the tobacco plant must be hunted and destroyed.

Topping, suckering and priming. — About two months after planting, flower buds appear at the top of the stalk, and these must now be pinched off. This process of " topping " forces all the growth into the leaves left on the plant, causing them to grow larger, thicker, and darker. Suckers will appear at the point where the flower stalk was broken off, and they must be removed as rapidly as they come. This process is called "suckering." The lower or ground leaves, which lie flat and rot, or get dirty and worm-eaten, also are removed, a process which is known as "priming." A favorite rule for the growers of heavy pipe tobacco is to "prime high and top low," but the growers of the brighter and more delicate cigarette tobaccos do not observe this rule.

After these operations some eight to twelve leaves are left on a plant, and these grow rapidly. The plants reach maturity about three months after being planted, and are then ready for harvesting. The leaves take on a yellowish green color and become thick and heavy, with small yellow flecks near the edges. The surface becomes gummy and oily, and as the days pass the oily substances increase and exudate. When these signs appear the grower knows that the harvest time is approaching, but it takes a vast amount of experience to decide on just the right color and stage of maturity before cutting. Just as there is a great difference in flavor and delicacy between fruit picked green and ripened on the shelf and that ripened on the tree, so there is a similar difference between tobacco picked green and that ripened on the plant. Sometimes separate leaves are gathered as they reach the stages of perfect ripeness, as to leave them on the stalk after they mature would be as detrimental as to pick them too early.

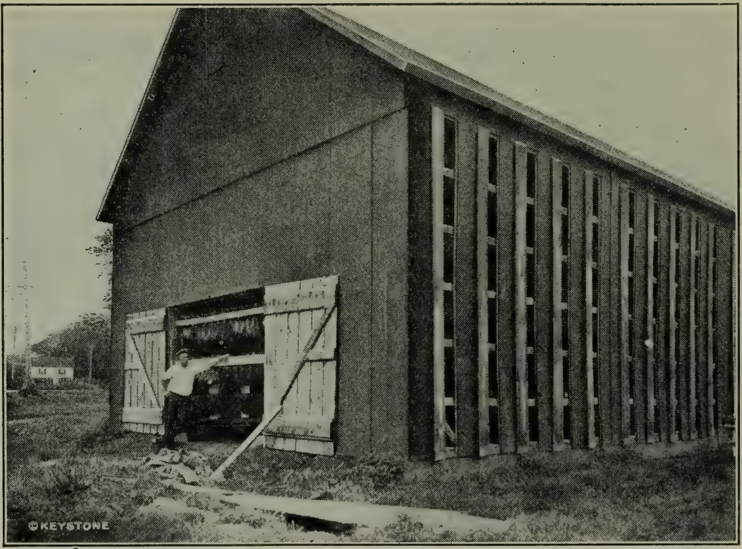
Harvesting Crop Tobacco in Wisconsin

Harvesting. — The usual method of harvesting is to split the stalk with a thin knife from the top nearly to the bottom leaves, and then to cut off the stalk below these leaves. The plants are then gently laid in rows to wilt in the sun until they may be handled without danger of breaking the leaves. But since too long exposure in the sun produces " sunburn," a cloudy day is usually selected for the cutting of the plants. The plants are then hung upon laths about four feet long, by means of nails driven into the lath, alternating on either side. Six to eight plants are hung upon each lath. These are now placed upon racks and hauled to the curing barn, where they are hung in tiers with a space of six to twelve inches between the laths.

During these three months or more between the preparation of the seedbed and harvesting the ripe plant the grower has been constantly employed. Much of the labor is handwork and can scarcely be turned over to machinery. The net labor expense, from the setting of the plants through harvesting, has been estimated at half the total cost of production.

Drying and curing. — " Growing tobacco," says Lock, " is but half the battle." Indeed the green and odorless leaf which is harvested is not technically considered tobacco until it is cured by a sweating process which gives it the characteristic tobacco color and flavor. The most trying and important time comes with the curing process, for the quality and value of the tobacco are determined in considerable measure by its outcome. The methods vary with the kind of tobacco, but the general principle is the same; natural or artificial heat is used to expel just sufficient sap to give the leaf the desired color, flavor, and elasticity. Two methods may be distinguished, according to whether artificial heat is, or is not, used.

Sun-cured or sun-dried tobacco is produced by the heat of the sun, and this process may be described first, as the simpler of the two. The tobacco plants are hung on scaffoldings on a wooden platform in the open air, screens being used to prevent them from being blown by the wind or disturbed in such a manner as to bruise the leaves. Four or five days' sun is sufficient, and the plants are then carefully transferred to a well-ventilated and well-lighted barn or house. During this period the leaves have been yellowing, and the greatest care must be taken to see that they do not cure so fast as to prevent the fixation of the desired color which results from the evaporation of the juices. Once transferred to the barn the curing of the leaves can be fairly accurately controlled. Ventilators are hung at regular distances on the sides of the barn, which is otherwise tightly built. If the curing season is a normal one these ventilators and the doors should be opened every morning, so as to permit a circulation of air between the layers of tobacco which will carry off the moisture, and closed every night. If the weather is very dry the reverse is done, in order to keep the leaves from getting too dry. After the tobacco is cured the barn should be kept closed.



A Tobacco-Curing Barn

The tobacco hung in this barn, near Hartford, Conn., will take about six weeks to cure correctly. The picture shows the slats on the side of the barn, by means of which the ventilation is controlled.

By the second method curing is done by artificial heat, which may be produced either by wood fires or by flues. In the former case a wood fire is kept burning for three or four days under the tobacco stalks hanging on the scaffold, until they are cured. By this method the leaf is given a strong flavor, which is preferred in the European markets; consequently most of the export tobacco is treated in this way. The distinctive feature of the flue method is that the curing barn is equipped with a system of pipes through which hot air of varying temperatures is passed from a furnace located outside. Since each stage of the curing process —

the yellowing, the fixing of the color, the curing of the leaf, and the curing of the stem — requires different degrees of heat, the merit of the flue system lies in the fact that the temperature, as well as the moisture, can be scientifically regulated. This method is usually followed in curing the " bright " cigarette tobaccos, which require more careful treatment. While it involves a larger capital investment, the greater certainty and accuracy of the results justify the outlay.

Stripping and bundling. — The process of *stripping* consists in breaking off the leaves of tobacco from the stalk. This cannot be done, however, until there comes a damp, foggy time or a rain, what is called a " tobacco season." The tobacco then absorbs enough moisture to become pliable, and can be stripped; under no circumstances should the tobacco be stripped when not pliant, that is if the leaves are so brittle that they would break when bent or rolled. In stripping, the stems of the leaves should be broken off as close as possible to the stalk.

When ten to fifteen leaves have been thus broken off they are formed into a *bundle* with the ends of the stems together and evenly placed; then another poorer leaf is wrapped around the stems so as to bind them together and cover up the ends, the end of the wrapping leaf being drawn through the bundle so as to hold it in place. Such a bundle is called a " hand " of tobacco. The hands may be strung on sticks, 18 to 20 on a stick, and hoisted up in the barn. The more usual practice at this stage is to pile the tobacco into heaps, or bulk it, before it again dries. The bulk is built on a platform slightly raised from the ground so as to permit a free circulation of air; the hands are carefully laid upon this with the butt ends out and are piled up into heaps from 4 to 8 feet high, depending upon the dryness of the tobacco. The whole is then covered by mats to check evaporation. The object of this process is to ferment the tobacco, so as to give it the right color. The temperature must be frequently tested with a thermometer and if it rises above about 114° F. the bulk must be torn down and rebuilt with the inside hands now on the outside.

Sorting and packing. — The process of *sorting* is often carried on at the same time that stripping takes place, but it seems the better practice to defer the sorting to a later period when it can be done more carefully. This consists in classifying the leaves according to quality and use, as into (1) first class leaves suitable for wrappers for cigars; (2) leaves of good quality but torn, suitable for fillers or cut tobacco; (3) leaves of inferior color and bottom leaves, used for smoking tobacco; and (4) refuse, shriveled-up leaves, and other poorer sorts. The hands are now pulled apart, and the leaves first graded for size, all leaves of the same length being put together. They are then classified according to quality, the sound leaves of even color and good texture being classed as wrappers, and the rest as seconds, etc. These groups are further divided into light and dark.

Loading Broad Leaf Tobacco in Connecticut

The tobacco is being loaded into a wagon, to be carried into the curing barn. The man in the picture is holding a lathe from which hang six strings of leaves. This is cigar tobacco.

After the tobacco has been sorted and graded it is tied with raffia into hands of one-fourth to one-half pound each, and is now ready for *packing*. In the United States tobacco is commonly packed in hogsheads, containing from 1000 to 1500 pounds. The method of packing is generally to place a double row of hands in the hogshead, with the butts outside at each end. Another row is then laid upon this at right angles, smaller hands being used to fill in the crevices. When a certain amount of tobacco has been laid in place, say 300 to 350 pounds, hydraulic pressure is applied to squeeze the whole tightly together. This is repeated until the hogshead is packed tight. Great care must be exercised at this point, for too great pressure causes blackening of the tobacco, and consequent deterioration in value. The hogshead is now given a number, the weight and grade are marked on it, and it is stored away in a dry place until sold.

In the heavy leaf districts, large quantities of tobacco are sold loose, before they are packed. In this case, the packing would be done by the purchaser. Further steps in the complicated processes of handling tobacco pertain to marketing and manufacturing, and do not concern the farmer; we may consequently take leave of the subject at this point.

Conclusion. — It is evident that the production of tobacco differs at many points from that of the great staple crops, wheat, maize, and cotton. As in the case of all luxury products, where the value of the article consists in the appeal which it makes to a fastidious demand, the utmost care and attention must be given to every step. There is here no large-scale, extensive cultivation, carried on largely by means of agricultural machinery, such as was found in the case of wheat and maize. Nor is the careless cultivation practiced in connection with cotton, permissible in tobacco growing. Every step in production, from the preparation of the soil to the final packing of the tobacco, calls for watchfulness lest the value of the product be lessened.

There is great specialization in the growing of different kinds of tobacco, but it is a specialization of product, not of processes. The requirements of the crop necessitate hand methods and prevent the use of labor-saving machinery, except in planting. There is consequently no large-scale production, nor division of labor. Nor is there any coöperation. Tobacco growing is a small-scale, difficult, and highly individualized industry.

SUGGESTIVE QUESTIONS

1. What was the importance of tobacco to the early American colonists?
2. Locate on an outline map the important tobacco-growing districts of the world.
3. Why can tobacco be grown as far north as Wisconsin?

4. What plant food does tobacco take from the soil in largest amounts?
5. Compare tobacco and the other staple crops as regards their effect upon the soil.
6. What is the disadvantage in bringing the subsoil to the surface?
7. Why are the tobacco seeds not planted directly in the field where the crop is to be grown?
8. What is meant by " sprouting the seed " ?
9. Describe the manner in which a transplanting machine operates.
10. What is a sucker?
11. Prepare an outline showing all of the operations involved in growing tobacco, from the preparation of the soil to the selling of the tobacco.
12. What kinds of tobacco are imported into the United States?
13. Do you know of any other agricultural crop which requires as much hand labor and is as subject to adverse conditions as tobacco?
14. Do you think the land and labor employed in growing tobacco might be better utilized in growing some other crop?
15. Get a leaf of tobacco, if possible, and take it to class.

BIBLIOGRAPHICAL NOTE

There is a voluminous literature on tobacco, but most of it is concerned with smoking, rather than with its production. Probably the best American book on the subject is J. B. Killebrew and H. Myrick, *Tobacco Leaf: Its Culture and Cure, Marketing and Manufacture* (New York, 1909). Other good books are W. A. Brennan, *Tobacco Leaves: Being a Book of Facts for Smokers* (Menasha, Wis., 1915), and C. Werner, *A Textbook on Tobacco* (New York, 1914). Another book by the latter author, of a popular character, is *Tobaccoland* (New York, 1922). W. W. Young, *The Story of the Cigarette* (New York, 1916), carries the story in interesting fashion back to the production of the tobacco. A good English book is C. G. W. Lock, *Tobacco Growing, Curing and Manufacturing* (London, 1903); less valuable is A. E. Tanner, *Tobacco* (London, 1912). The marketing and manufacture of tobacco, with emphasis upon labor conditions, are treated best by M. Jacobstein, *The Tobacco Industry in the United States* (New York, 1907). Valuable information on tobacco growing may be obtained from the United States Department of Agriculture; especial mention may be made of Bureau of Plant Industry Bulletin 96 on *Tobacco Breeding;* also of Farmers' Bulletins 6 and 60.

PART V

MAN'S CONQUEST OF THE MATERIAL WORLD

CHAPTER XXV

THE MACHINE PROCESS

Dominance of the machine process in modern industry. — The most characteristic feature of modern industry is the use of machinery. It is true that there are some processes in which hand labor still prevails and in which few machines are used, but in manufacturing and transportation industries the use of machinery is universal. In the extractive and genetic industries it finds smaller application, and is least employed in personal and professional service, but even in these its use is growing both in quantity and complexity. The modern economic organization in the United States and Western Europe to-day is sharply distinguished from all previous systems of industry and from those in the larger part of Asia and Africa of the present day by the general use of machine processes. The modern industrial system is frequently called the " capitalistic system," because of the large amounts of capital employed in production, much of which consists of machines; and the period in which we live is called the " machine age " because so much of the work of to-day is done by machines.

The processes of modern industry rest upon the machine technique. Machinery has given to modern industry its characteristic features and its scope and method. It has been the chief influence in the development of what is called modern capitalism and is responsible for most of the advantages and evils inherent in the capitalistic system. Those industries in which the use of machinery is important, are to-day in a dominant position, setting the pace for the remainder of the industrial world.

Industry before the age of machinery. — Before the Industrial Revolution, which occurred in England in the latter part of the eighteenth century and which ushered in the modern machine era, industry was carried on, for the most part, with relatively simple tools. A tool is a comparatively simple instrument for aiding or augmenting the natural powers of man, and is used directly by the worker. Such articles as a hammer, a knife, a spear, or a sword are simple tools, and the power which gives them force and direction is human muscle and skill. They may be regarded as the extension and peculiar shaping of the arm of the worker. Thus a hammer is, after all, only the fist of a man, lengthened and hardened; the knife is his finger, sharpened and straightened; and similarly with other tools.

Some tools are more complex than the ones just mentioned; such are the hand loom and the potter's wheel. But even here man furnishes the motive power and guides and directs the tool.

The definition of a machine. — A machine is a device designed to transform or transfer energy and to apply power to the production of utilities or goods. The power may be that of man or it may be non-human power such as the force of winds, water, steam, or electricity. An example of the former case would be a domestic sewing machine and of the latter a power loom or a modern printing press. But in either case the significant characteristic of the machine is that it does not, like the tool, involve an application of human muscle or skill directly upon the raw material. The machine itself embodies certain forces and performs certain acts; the man in charge of a machine determines whether it shall act, but to a much smaller degree how it shall act. In using a tool the worker determines both when and how it shall perform.

There are two types of machines, simple and complex. Of the simple machines there are six: the lever, inclined plane, wedge, screw, pulley, and wheel and axle. Complex machines are only combinations of two or more of these simple ones.

Modern machinery, according to Karl Marx,[1] consists of three distinct yet mechanically connected parts: the motor mechanism, the transmitting mechanism, and the tool or working machine. The motor mechanism puts the machine in operation; and it either generates its own power as does the steam engine, or uses some existing natural force as does the water-wheel. The transmitting mechanism, which is composed of drive-wheels, shafts, pulleys, belts, pinions, and gearings, regulates the motion, changes its forms or direction where necessary, and distributes it among the working machines. The working machine is the part of the entire machine concerned with working up the raw products and giving to them their characteristic shapes and appearances. The first two parts exist only for putting the working machine in motion.

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[1] *Capital,* p. 267.

The difference between a tool-using and a machine-using society. — It is not possible to draw a hard and fast line between a tool and a machine, but enough has been said to make clear the most significant difference. A tool is put in action by human energy and a machine is driven by power, generally non-human. An industrial society which uses only tools is limited by the numbers of pairs of hands that can employ them. The productive capacity of such a society is measured by the size of the population and the strength and skill of the workers. If it is unaided by the labor of domestic animals of draught and of burden, as was the case with the North American Indians, such a society is greatly handicapped in its progress toward civilization. It will probably be unable to produce more than enough to meet its most urgent needs for food, clothing, and shelter. Even in the cases of those people which have had the assistance of such useful domestic animals as the ox, the ass, the camel, or the elephant, a tool-using society is definitely limited in its production by the fund of human energy at its disposal.

In the case of a machine-using society, however, the only limit upon its productive capacity is its ability to harness the forces of nature and to apply this non-human power to the work of production. Its output is no longer limited by the physical strength or skill of its workers, but rather by the mental ability and inventive genius of all its members. Once a society has passed from the tool to the machine stage of industry its powers of production not only increase, but the human limit upon its productive capacity is greatly reduced. A modern machine-using society may well be likened to Aladdin, who had only to rub his magic lamp to have the genie do his bidding.

A machine is crystallized thought. — The product made by means of a tool is the expression of the mind and will of the man who fashions it, the man who is using the tool. The machine-made product, on the other hand, cannot be said to represent the ideas or the purpose of the man in charge of the machine, who is, in the case of complex machinery, merely a machine tender. Rather the machine represents the stored and concentrated effort of the inventor, who now endlessly expresses his thought and purpose in the operations of the machine. The more complex and automatic the machine, the more is the will of the inventor expressed and less that of the immediate worker or machine tender. A machine-using society is thus able to accumulate the efforts of its members, to store them up in machines, and to release them as needed. The advantage which such a society possesses over one which is restricted to the use of tools lies, therefore, not so much in its superior productivity, great as this is, as in the fact that it can accumulate the experience of past ages for service at the present.

Such crystallizing of the inventor's thought in a machine does not in itself produce anything. The machine must be driven by non-human power if it is to operate efficiently, and it must take its proper place in the industrial scheme. These points are so important that separate chapters will be devoted to each. The remainder of this chapter will be restricted to machinery and the machine process; the following chapter will describe inventions, or the growth of the mechanical apparatus of modern industry; and the next will treat the development of non-human power.

Conditions of machine industry. — Not all products are equally well adapted to manufacture by machine processes. Machinery can be applied in an industry making a standard product for which there is a steady demand better than in one where individual tastes are an important factor or where fashion changes often. Under such conditions demand is irregular and the purchase of expensive machines for such work might be a losing proposition.

Non-uniformity of the raw material used or in the nature of the work is a factor which may retard the use of machinery in an industry. The processes of agriculture have been slow to pass under steam power for this reason. Where there is sorting or grading of material as to quality, machinery is not practicable. If, however, it is to be graded merely according to size machinery can be used. Machinery has been applied more slowly in, say, tanning hides than in many other industries because of the irregularities in the material to be worked upon.

The durability of the product is also a factor in determining whether or not machinery may be employed on a large scale. Hand work is necessary where products are fragile, as in the case of paper flowers, or perishable, as in the case of fresh fruit or fish.

If the article is to be canned, machine method may be used, but the attribute of perishability is then missing. Otherwise it would not be practicable to do so.

In a region where there is an abundance of cheap labor and where the work involved is light or does not require much skill, the introduction of machinery is generally slow. Machinery has, in many cases, been employed to avoid paying high wages to laborers. If labor is plentiful and cheap, it may be cheaper than machinery and will be used more. This is true especially in trades where women and children are able to perform the majority of the operations involved.

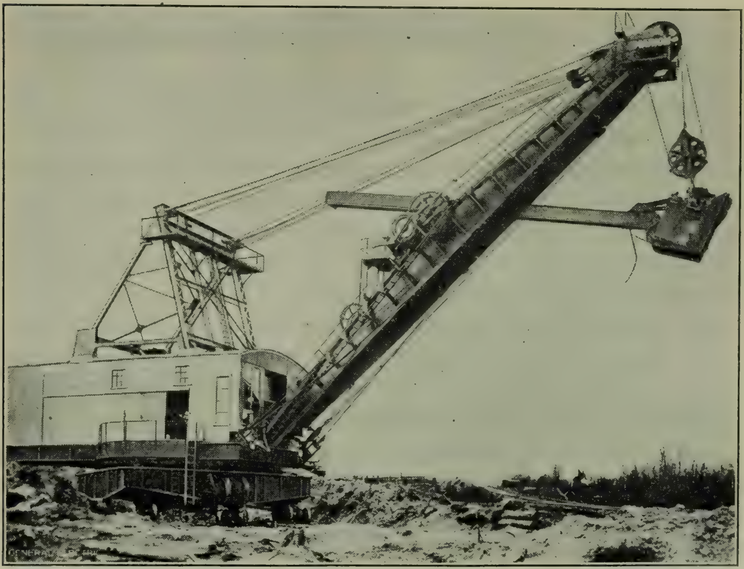
Neither can machinery be employed advantageously where high skill or the element of art enters into the making of the product. In the manufacture of pottery and glassware, there are many processes which cannot be carried on without human skill. When machinery is employed, it is in connection with some invention made for a particular purpose rather than the general adoption of machine methods and motor power.

The technical superiority of machinery. — A machine is a vastly more efficient instrument of production than a tool used by even a highly skilled hand worker. This technical superiority manifests itself in several different ways.

1. By the use of machinery *power can be concentrated* and massed at a given point to an extent impossible for human beings. Thus the steam hammer can provide force for a given task no number of men, however large, working with hand hammers could produce. The impossibility of any considerable number concentrating their blows at a particular point places a physical limitation upon the summation of human power. The Panama Canal had to wait for the invention of the steam shovel and similar machines. A modern ocean steamship could not be propelled by a hundred thousand rowers so fast as it can be by a steam turbine. Other illustrations may be found in the hydraulic press, the rolling mill, and similar machines.

2. Great *precision* and *accuracy* are made possible by machinery. It is difficult for human hands to maintain a precise repetition of the same movement or an even, accurate pressure for any considerable length of time. The machine has a distinct advantage over hand labor where exactness of measurement is desired. The classic example of this is the watchmaking industry. Fifty years

ago the chief seat of this business was Switzerland, where a high degree of manual skill had been developed among the hand workers; the trade had been divided into about fifty distinct branches, each of which did a small part of the work with great expertness. To-day this industry has yielded its preëminence to the American system of making watches by machinery, by means of which results utterly unattainable by human hands have been accomplished.



ELECTRIC SHOVEL

A hand shovelful of ore weighs 21 pounds, and a man can handle 200 shovelfuls in an hour. But this giant electric shovel, one of the largest one-man shovels in the world, used on the Mesabi Range in Minnesota, can pick up 16 tons of ore at a bite, which it deposits in a car in less than a minute. This is more than a man can excavate in a day.

In the United States one man with the aid of machinery can produce 150 watches per year while in Switzerland by hand methods he can produce only 40. " By the aid of special machinery in these watch factories one can make 1200 fine screws per day, some of which are so small that more than 100,000 are required to weigh a pound. One of the finest pieces made is a " pallet-arbor " or pivotal bolt which for a small sized watch has a thread of 260 to the inch, weighs 1/130,000 of a pound, undergoes 25 operations and costs but 2¼ cents. Measurements are gaged to 1/25,000 of an inch.

"The balance wheel, after being machined, weighs only 7 grains, and when fitted with 16 gold screws 7.2 grains; there are 80 separate operations upon a balance wheel, 60 of them being drilling, threading, and counter-sinking holes; the drills revolve at a speed of 4,800 turns a minute, and one operator can drill upward of 2200 holes for balance wheels per day."[2]

3. Closely related to this is the ability to produce by machinery any number of articles of uniform size, or weight, or design. It is all but impossible to ensure absolute *uniformity* by hand methods, but this can be accomplished, without the slightest deviation from the model, by a machine. "The hand of the most highly skilled workman," says Gide, "can reach a degree of precision of 1/200 of an inch, but it will not succeed in making two identical parts. Machinery does this, and cannot do otherwise." When Boulton and Watt started to manufacture steam engines they experienced the utmost difficulty in having parts made which would fit. They met this by confining each workman to a particular task in which he became so expert that he was able to turn out parts which were similar if not identical. Contrast with this the absolute assurance of the modern manufacturer that every nut or bolt or screw of a particular kind will be uniform with every other one turned out by the particular machine.

This principle of the *identity* of all the products turned out by the same machine pervades most manufactures, and is based upon the faithful reproduction of the model in the manufactured articles. If a large number of articles is to be produced, it is worth while to expend a considerable amount of labor and capital in fashioning the original, and the model may cost ten or twenty thousand times as much as each subsequent article. Beauty of form and proportion may be given to the manufactured products by exercising due care in making the model. Illustrations of this principle are found in printing of all kinds, in casting iron and other metals, in moulding bricks, pottery, etc., in stamping, punching, turning, and cutting by machinery.

Machines not only turn out a uniform product, but they are *dependable,* tireless, and unaffected by ordinary human weak-nesses. As agents of production they are therefore technically superior to weak, fallible human beings, who are not merely subject to ills of the flesh but who may also strike or resign their jobs.

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[2] Alexander E. Outerbridge — *Annals of the American Academy of Political and Social Science,* Jan.-June 1905, Vol. 25 p. 48.

4. Much greater *speed* can be obtained in the work of production by using machines instead of hand labor. A turbine, making 140 revolutions a second, cannot be followed by the human eye, much less by the human hand; and the same thing is true of a cotton spindle, a boring machine, an electric riveter, and many other machines. It is thus possible to accomplish by a machine in a few minutes a task which would require hours if undertaken by hand methods. There results a great saving of time.

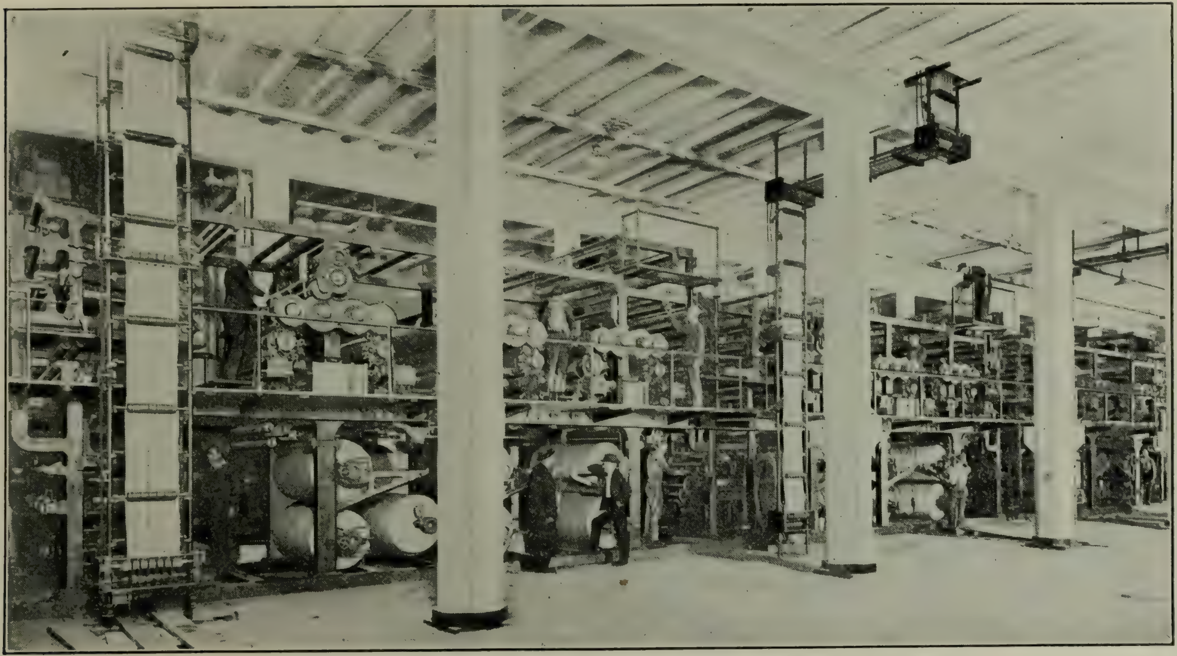
In some cases this saving of time is essential. Thus agricultural machinery has made possible the harvesting of the grain crops at the time of maturity, while if hand methods were used a large proportion would be damaged by rain or frost and lost. Twenty times the number of men now employed in agriculture would be required to produce our food supply if hand methods were the only ones available.

Machinery also *extends the time of the action of the force.* Thus a small amount of time and effort is needed to wind up a watch or a clock, but the effect is spread over a day or a week. This same principle is applied in any machines which operate by means of a spring.

5. " One of the most singular advantages we derive from machinery," says Babbage, " is in the *check* which it affords against the inattention, the idleness, or the knavery of human agents." It seems almost as though machinery were the master and registered human actions. The use of water, gas, and electric meters, alarm clocks, time clocks, alarms on typewriters, cash registers, and the multigraph for stamping the amounts on bank checks are illustrations.

But machinery can also *register* the results of its own movements; it can count the number of units which it produces. Thus the newspapers printed on a modern press are not only printed, but are folded and counted.

6. The height of the technical superiority of machinery over hand labor is reached in the case of self-regulating, automatic machines. *Self-regulation* is the highest achievement of the inventor in the expression of his purpose in the machine. An automatic machine, such as the modern printing press used by large metropolitan daily



A MODERN PRINTING PRESS — LOS ANGELES HERALD

Such a press as here pictured will print, fold, and deliver over 300,000 pages of finished newspapers an hour.

newspapers, performs every action, after the raw material is put in place and the motor started, without the assistance of human hands. Should the supply of material give out, or anything go wrong with the work, the machine automatically stops.

Although the principle had been early introduced in machinery, as illustrated by the governor in the steam engine, its common application began, according to Arthur Pound,[3] in the late eighties when the moulding machine first appeared in American foundries. This was quickly followed by the turret lathe, the screw machine, the pneumatic hammer, the grinding machine, and scores of others. Automatic machinery was given wide scope by the development of the automobile, with its need for quantity production, standardization of parts, and extreme accuracy; and still further stimulus was given by the World War with its unprecedented demand for enormous quantities of uniform products of many kinds. The automatization of machine production has had, and is having, profound effects upon the quantity and cost of production and upon the worker, which is not confined to the factory workers only. Adding machines, manifolding devices, and other semi-automatic machines are also an accepted part of the equipment of any modern office.

Economic advantages of machinery. — The greatest advantage which machinery possesses for society as a whole lies in the fact that it produces more cheaply than do hand processes. This cheapness is due to the following causes:

1. Machinery *economizes* in the use of *raw material* and of former *waste products.* Illustrations of the economies effected in the use of raw materials may be found in the substitution of the sawmill for the broad ax in fashioning boards, of the steam die for the tailor's shears in cutting garments, of the rockdrill for the pick, and many others. In all these cases there is less waste in getting out or utilizing the raw material.

Many products formerly regarded as " waste " and which were unavailable so long as hand processes prevailed, can now be utilized with the aid of machinery. Thus the free nitrogen of the air can now be fixed and used as fertilizer. Coal gas and coal tar were discarded until science with the aid of machinery utilized them as the bases of industries manufacturing dyes, chemicals, phar-

[3] *The Iron Man,* p. 3.

maceutical products, and other valuable articles. Similar illustrations could be drawn from almost any large industry.

2. Another economy effected by machinery is the *saving of human labor*. Less labor is needed in the production of a given quantity of goods by means of machinery — even counting in the labor involved in the making of the machine — than by hand methods. It is possible to substitute mechanical power for human power as a motive force, and frequently to substitute a weaker kind of human power for a stronger kind, as when children or women run machines to manufacture products which previously only men could produce. It is also possible sometimes to dispense with a large amount of labor in the direction and control of processes, as in the case of the semi-automatic machinery described above.

This saving of labor may be illustrated from an investigation made some years ago by the United States Commissioner of Labor. In the manufacture of a certain quantity of house brooms the number of hours of labor required was reduced from 445, which was necessary when hand labor was used, to 295 when machinery was employed; in the manufacture of a farm wagon from 221 to 48; for making a dozen pairs of knit woolen gloves from 360 to 8; for shelling 100 bushels of peas from 175 to 1; for making 25,000 pounds of soap from 432 to 21; for manufacturing 100,000 cigarettes from 520 to 14; for crushing 100 cubic yards of stone from 630 to 10; for unloading 100 bales of cotton from a ship from 120 to 37; and for loading 1000 bushels of wheat from an elevator to a ship from 37 to 9 hours.

The labor thus set free from the tasks now performed by machinery may be applied to the production of other goods, not before possible, and the machine-using society made richer thereby, or the hours of labor may be reduced and the society may enjoy more leisure instead of multiplying goods. As a matter of fact both things have usually been done at the same time.

3. A third reason for the greater cheapness of machine-made goods is the greater *productivity of machinery* as compared with hand methods. All the advantages cited above, as technical superiorities of machines over human muscle and skill, indicate the extent and reason of this greater productivity. A single illustration will be sufficient. Some years ago the Department of Labor of the United States investigated this point and studied the quantity of agricultural crops which could be produced by the hand methods

prevailing in 1829–1830 and by the machine methods of 1896. The conclusion was reached that the former methods would have produced a crop of barley of 2,972,839 bushels while the latter actually produced 69,695,223. In the case of hay the two amounts were 8,801,640 tons and 47,078,541 tons; and in the case of wheat 23,245,490 bushels and 427,684,346 bushels. Here was an increase in product of about twenty times for barley and wheat and five times for hay due to the substitution of machinery for hand labor.[4]

These are extreme cases, but similar illustrations may be drawn from transportation, manufacturing, and even personal and professional services. A society which is equipped with machinery is vastly more productive than one which must rely solely upon hand methods. Its wealth and income are both greater.

Disadvantages of machine industry. — The advantages to be derived from the introduction and use of machinery are social in their nature, that is the whole of society is benefited. It is claimed, however, that these benefits are purchased at the expense of one class in society, the workers, and that these suffer corresponding disadvantages. The following evils have been charged against machinery:

1. It is charged that machinery *displaces human labor,* and that the gains go to the employers rather than to the workers. Several answers are usually made to this charge. In the first place the gain does not go entirely to the employers but is distributed to the whole of society through lower prices; as consumers the workers share in the benefits of lower prices and higher standards of living. Secondly, there is not a decrease, but an actual increase in the number of workers in machine industries; thus after the invention of printing there were more printers than there had been copyists; after the invention of the steam locomotive more men were employed on the railroads than had previously found work as coachmen, postillions, and hostlers: and after the invention of textile machinery the number of textile workers increased. Although these examples are all taken from industries for whose product there is an expansive or elastic demand, it may fairly be urged that this tendency holds for industry as a whole in spite of exceptions.

It must not be overlooked, moreover, that the greatest benefit of machine industry is that it produces a larger output with a smaller expenditure of human energy. To allege as an evil the fact that

[4] See *Thirteenth Annual Report.*

men are released from toil and that their work is handed over to machines is to claim that work is desirable for its own sake and that anything which reduces the amount of human labor necessary to satisfy our wants is undesirable.

2. A second charge against machinery is that it tends to displace skilled by unskilled labor and thus *lessens the demand for skilled labor.* Relatively little skill is required to operate an automatic machine and not much time is needed to acquire the necessary proficiency. Machine production is usually accompanied by considerable specialization of labor, and in this case the operator is confined to a single operation or the management of a single machine. This makes the development of all-around skill, such as characterized the old-fashioned mechanic, impracticable and unnecessary. Frequently the machine tender does not even have to repair his machine, which is done by another specialist, but is restricted to feeding in raw material and removing finished articles. The machine worker therefore tends to become, it is claimed, not merely highly specialized but also without fundamental training in industrial processes. Such a man is much more dependent industrially, and has an instable and uncertain position in modern industry.

3. A third charge against machinery is that it causes work to be monotonous and that this *monotony of work* stunts and degrades the laborer. In machine industry the worker may have just one operation to perform all day long, and as he cannot change his occupation or vary his speed but must follow the pace set by the machine, the work becomes irksome. In addition to the fatigue which may be caused by high-speed machinery, there is a certain mental and nervous wear and tear due to monotony of work. In modern industry fatigue is frequently due more to the sameness of movement than to the expenditure of physical energy, for machinery has done much to relieve the workers of the former muscular strains.

Another evil grows out of this monotony of movement. This is its effect upon the minds of the machine operators. Machines, especially those of an automatic character, make comparatively slight demands upon the mentality of the operators. Once a person has learned the requirements of the machine, he can work with little further mental effort, and, unless he is an unusual man, there is no development of his individuality and initiative. Under such conditions, it is claimed, the intellect becomes dulled and the worker becomes a mere machine tender.

Automatic machine tools. — The important part played by machinery in modern industry has been pointed out in the preceding pages. But the great influence which machine tools have exercised in the development of machinery remains to be pointed out. Unless precise machine tools had been developed, machinery could not have been carried very far, for it is with machine tools that all other machinery is produced. This may be illustrated by the history of the greatest of all machines, the steam engine.

When Watt invented his steam engine he was able to make a small model which was successful, but when he attempted to reproduce his model on a large scale he was unable to get a cylinder bored with sufficient accuracy to have the piston fit in it tight enough to keep the steam from escaping. For ten years he struggled, wrapping the piston about with cork, rags, paper, tow, and other things, but had finally to put up with a rough hammered cylinder. Success was not achieved until John Wilkinson invented a boring machine, which bored out the cylinders almost without error. This was " probably the first metal-working tool capable of doing large, heavy work with anything like present-day accuracy."[5] According to Roe, the tools in use at the close of the eighteenth century were crude affairs, and machinery was constructed as far as possible of wood, as metal could not be worked by these hand tools. " There were a few rude drilling and boring machines, but no planing machines, either for metal or wood. The tool equipment of the machinist, or ' millwright,' as he was called, consisted chiefly of a hammer, chisel, and file."

The nineteenth century has seen the development of machine tools to a point where the modern machinist can command at the same time enormous power and also precision, can work in metal almost as readily as in wood, and can entrust the performance of many tasks to automatic devices. The equipment of a modern machine shop includes such machine tools as the boring machine, engine lathe, automatic lathe shaper, miller, the steam hammer, the drop hammer, limit gages, and standard taps and dies.

" The one machine tool," writes Woodworth,[6] " which has contributed more than all others to the attainment of results in modern tool-making is the milling-machine. . . . Although the youngest of the machine-tool brood, it is now the most universally used one and can well be placed at the lead of them all." The feature which makes the miller, the turret lathe, and similar machines capable of producing such exact and automatic work is the installation of guide screws and geometrical controlling devices, which substitute for the uncertain hand or fallible judgment of the operator the control of the machine itself. With such accuracy is a modern master machine constructed that it will produce parts which gage true to a ten-thousandth of an inch, and even to the hundred-thousandth part of an inch. This last is the two-hundredth part of the diameter of a human hair. Such machines are not only exact, and complex, but they are also automatic. " The turret lathe feeds itself, each tool is brought into play in its proper order, and with an appropriate traversing motion. It can make the hub of a cycle wheel, for instance, straight from a bar of steel and without any human interference; and one competent man can be responsible for twelve lathes." [7]

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[5] J. W. Roe: *English and American Tool Builders* (New Haven, 1916) p. 3.

[6] J. V. Woodworth: *American Tool Making and Interchangeable Manufacturing* (N. Y. 1911) p. 120.

Interchangeable parts. — In many articles of a high grade, which are made in large quantities, it has been found very advantageous to have the corresponding parts so nearly alike that any one of the identical parts could be fitted equally well into any one of the articles. This can be done only with the aid of precision machine tools and machine methods which give a degree of accuracy and uniformity which cannot be obtained by hand methods. Under a system of manufacture by hand each part is a specialized product which is fitted to its neighbors, and the loss of a single important part will put the entire article out of use until it is repaired. The delay thus occasioned in the use of a machine, as in a reaper in harvest time, may result in considerable loss as well as inconvenience. Under a system of interchangeable parts, a new piece can be installed in a short time to replace the broken part, with little delay in operation.

There is a rough kind of interchangeability among the bricks used in building a wall or the sections of pipe used in constructing a sewer, but this is not what is meant by interchangeability in manufacture. In interchangeable manufacture the parts are closely articulated and constitute a permanent element of the machine or mechanism, as in firearms, sewing machines, typewriters, cash registers, machine-made watches, bicycles, automobiles, and many other articles.

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[7] Alfred Marshall: *Trade and Industry*. (London, 1920) p. 209.

The first suggestion of the idea of the interchangeable system seems to have been made in France in connection with the manufacture of guns in the eighteenth century, but the practical application was made in the United States by Eli Whitney in 1798, also in connection with the manufacture of guns. In that year he obtained a contract with the United States Government to manufacture some 10,000 muskets in which he proposed to introduce a new plan which would " make the same parts of different guns, as the locks, for example, as much like each other as the successive impressions of a copper-plate engraving." Whitney was very successful and the interchangeable system was introduced generally into the Government armories and private establishments for the manufacture of firearms. After the middle of the century this method spread to Europe where it was known as the " American system," and was also introduced into other branches of manufacturing.

Economically the importance of this system lies in the lessened cost of production and in the rapidity and ease of repair, so that articles made with interchangeable parts find a wide distribution. But from an industrial standpoint the system has been made possible only by the invention and improvements of machine tools. Until these were perfected it was impossible to manufacture the parts of intricate machines and pieces of mechanism, such as a complete harvester or an automobile, with the requisite precision and accuracy. With the development and spread of machine methods in modern industry our dependence upon the perfection of the mechanical equipment with which society performs its work has steadily increased. We are impressed by the results of this system, but are apt to overlook or under-emphasize the means by which they are accomplished. The system of interchangeable parts marked a long step forward in economy of machine production, but even more important was the perfection of the tools and machines which made this possible.

SUGGESTIVE QUESTIONS

1. Name some industrial process or services which are performed absolutely without the aid of any machine or tools.
2. Name some types of work, now done by hand, which you think a machine might do.
3. Illustrate the standardization of products by the case of automobiles; of screws; of note-books.
4. What is the distinction between technical superiority and economic advantage of machinery?
5. Which of the various kinds of technical superiority of the machine seems to you the most important? Why?
6. Give illustrations, other than those in the text, of machines which possess each one of the points of technical superiority.
7. Does it seem to you that the economic advantages or disadvantages of machines are greater?
8. If you broke your bicycle or your watch, would it be difficult to have the broken part replaced?
9. Machine industry did not spread rapidly until machines were made to make machines. Why?
10. Are there any reasons why an employer might prefer to employ machines rather than persons?
11. Does the prevalence of machinery in modern industry suggest the character of the training you should receive for your life work?
12. Is machinery used only in work, or does it help us to enjoy our leisure time also?
13. Do you think that machinery has standardized life, or that it has introduced more variety into it?
14. Have machine methods influenced our mental outlook, inclining us all to conform to set patterns in behavior, dress, ideas, and similar things?
15. At present compressed-air painting machines can be used for only a few hours each day. How do you account for this?
16. Large corporations often buy and then suppress the patents on new machines. Why do they do this?

BIBLIOGRAPHICAL NOTE

There is a considerable literature upon machinery and its effects, but it is for the most part controversial and unscientific. One of the best books written on this subject is also one of the first: Charles Babbage, *On the Economy of Machinery and Manufactures* (London, 1832; 3rd ed., 1833). Less scholarly but historically valuable, is C. Knight, *The Results of Machinery* (London, 2nd ed., 1831). No recent writer has more clearly grasped the principles of modern technology and applied them to economics than has Alfred Marshall in his *Industry and Trade* (London, 1920). Of American writers there should be named J. M. Clark, *The Empire of the Machine* (New York, 1925). Arthur Pound, *The Iron Man* (Boston, 1922), emphasizes the effect of machinery upon labor, and J. A. Hobson, *The Evolution of Modern Capitalism: A Study of Machine Production* (London, rev. ed., 1907), also writes from the social point of view. A detailed statistical study of the economies of machine, as compared with hand, methods of manufacture is *Hand and Machine Labor* (U. S. Bur. of Lab. Stat., Washington, 1899). Many of the systematic books on the principles of economics have single chapters on this subject; among these may be mentioned L. C. Marshall and L. S. Lyon, *Our Economic Organization* (New York, 1921).

The best books on machine tools are J. W. Roe, *English and American Tool Builders* (New Haven, 1916), and J. V. Woodworth, *American Tool Making and Interchangeable Manufacturing* (New York, 1911).

CHAPTER XXVI

INVENTION

The permanency of ideas. — In the previous chapter the statement was made that a machine represents the thought of the inventor, who expresses his purpose in the operations of the machine. A machine is after all only an inert piece of mechanism; its usefulness and efficiency depend wholly upon the ability of the inventor to design it so that it will carry out his purpose and operate according to his plans. Back of the machine lies always an idea and the power of the human mind. The thought of the inventor is therefore the mainspring of industrial progress and is far more permanent than the material appliances through which and by means of which it expresses itself.

It has been estimated that the average life of industrial capital, in the form of machines, railways, ships, and other appliances, is about five years. That is to say, if no additions or replacements were made to take care of use, depreciation, destruction, etc., in about five years the capital of any society would be used up, and it would be necessary to reconstruct these things. This was well illustrated by events in Russia after the revolution of 1917. The railway bed and equipment were used, but were not kept up by constant repairs and renewals. When an engine got out of order it was run onto a siding; when a freight car was damaged it was ditched at the side of the road. The result was that in about five years the railways of the country, as effective agencies of transportation, were almost used up.

This incident is cited to emphasize the point that the mechanical appliances of our modern machine age are short-lived. Outside of a few buildings and some well-made roads, little of the capital produced in previous centuries is in actual use to-day. The permanent and imperishable legacy which modern society has inherited from the past has been rather a stock of ideas, discoveries, and inventions. If all the material wealth in any modern industrial nation were suddenly destroyed by a catastrophe, but the people were unhurt, it would be but a comparatively few years before the buildings, machines, railways, etc., would be rebuilt. Witness the rebuilding of Chicago in 1871, of San Francisco in 1906, or the restoration of the devastated regions in France after the World War. If, on the other hand, by some sudden catastrophe all the scientific knowledge which has accumulated through the centuries, were lost to man, the existing machines would be unused or destroyed, the buildings would soon fall in ruins, and man would revert to a stage of savagery. Attila and his Huns did not use the appliances of Roman civilization because they did not understand them.

The immaterial part of modern civilization, consisting of ideas, discoveries, and inventions are therefore found to be, paradoxically enough, the most enduring and imperishable, while the material things of fiber and wood and iron serve their brief purpose and then pass away.

Importance of invention. — Man is distinguished from animals, according to Professor E. B. Tylor,[1] not so much by his use of tools, for this is true of some apes and other animals, as by his ability to make tools. Carrying this idea a step farther, it may be said that man emerged from savagery to barbarism, and from the latter stage to civilization, only so fast as he made new inventions or innovations which enabled him better to cope with nature and with his enemies. While invention has been only one of many factors which have made for human progress, it is the one which more than any other has contributed to man's economic advancement. It may safely be asserted that to-day the factor which distinguishes backward races from those more advanced, conquered races from their conquerors, poor peoples from prosperous, is the extent to which the latter groups have made the forces of nature do useful work for them. The exploring, conquering, exploiting, manufacturing, merchandising, and investing of the most powerful nations of the world to-day have all been forms of invention or have involved new inventions, using this word in a very broad sense.

It is only by invention and discovery that man is able to extend his knowledge of the physical world and his mastery of natural forces. By invention he has learned to extract aluminum from common clay, perfumes and dyes from coal, nitrogen from the air, and even gold from sea water. But, in spite of our vaunted progress

[1] *Anthropology,* p. 183.

we have actually utilized only a fraction of the resources which nature has provided. " Out of the 140,000 known varieties of the vegetable kingdom," writes Professor Gide,[2] " less than 300 are cultivated; and out of the hundreds of thousands of species in the animal kingdom there are barely 200 that we have learned to utilize." And it may be added that we make commercial use of a still smaller proportion of the known minerals and metals. As new inventions and discoveries are made new uses are found for objects which were formerly considered useless, and the wealth of man is thereby increased.

Why are inventions made? — One answer is, invention is due to an occasional genius. It is true that sometimes a genius is born whose contributions are so unusual and epoch-making that his appearance marks a stage in human civilization. Such a genius was Archimedes. For the most part, however, the work of invention is carried on by men of a lesser breed. The explanation of the manifestations of inventive genius, Professor Taussig[3] finds first of all in an instinct of contrivance which impels certain individuals to find their greatest happiness and self-expression in work of this character. The great inventors have not merely had a bent; they have obeyed an inborn and irresistible impulse, which has found expression in many directions. A genius never stops with one invention, but is continually experimenting with new problems after one is solved.

Illustrations of such men are easily found in the histories of invention. Professor Taussig instances several cases, of which the following description of Cartwright, taken from an old memoir,[4] is typical:

" Cartwright never ceased inventing. When he settled down in London he set himself to the systematic pursuit of scientific discovery. . . . His little house in Marylebone Fields became a very treasure-house of arts and sciences; nothing was too little and nothing too great for him to exercise his ingenuity upon. He made bread in his own kitchen by machinery, published a scheme for rendering houses fire-proof; invented bricks on a geometrical system; made a machine for biscuit baking; helped Fulton with his first steamship models; brought chemistry to bear upon the science of agriculture, introduced a new three-furrow plough; got the Agricultural Board's gold medal for experiments in manure, and their silver medal for an essay on the culture of potatoes; and obtained patents for calendering linens, making ropes, and cutting velvet pile."

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[2] *Principles of Political Economy,* p. 88.

[3] *Inventors and Money Makers,* p. 11.

[4] *Memoir of Edward Cartwright* (1843), p. 17, quoted by F. W. Taussig, *Inventors and Money Makers,* p. 25.

Necessity is the mother of invention. — The popular explanation of invention is that it is caused by necessity or some emergency which must be met and overcome. Warrant for this is found in some typical explanations of the reasons given by women for inventing certain farm appliances:[5]

" A Florida woman who invented a device for distributing fertilizer answers the question, " What circumstances led you to invent a fertilizer distributor," thus:

" ' Yankee laziness, I reckon. I didn't like the idea of bending my back so much, hence the distributor.'

" A Texas woman who secured letters patent for a new and useful improvement on a cultivator tongue writes:

" ' Having been raised on a farm and seeing that there was needed improvement on cultivator tongues, I made up my mind to improve on the old style tongue.'

" Another Texas woman writes about the circumstances surrounding the invention of a sugar-cane stripper:

" ' I was farming in 1916 and planted sugar cane to make molasses. When time came to strip cane I was short of help and I shirked the old tiresome way of stripping cane. I then studied out a new way. . . . After three trials I had what I needed. I had it to work perfect and I could do with it as much as four persons could do in the same length of time in the old way and make a better job of the work of stripping, as it saved labor, prevented backache, sore hands, and the worn-out tired feeling! ' "

In these homely illustrations is embodied a profound truth. The direction of progress in invention, according to Professor Hayes, is determined by two sets of factors: wants and occasions. " Under the spur of *wants* experimentation redoubles, constructive imagination makes its short leaps, and along the hot association paths old elements, or old and new, shoot together into new combinations. This special heating up of special areas of mental activity we call attention. Attention is the mother of invention, want is its grandmother."[6] The occasion which brings special stimulation to attention and imagination may be any kind of crisis in which the old habits or methods prove unsatisfactory; then inventions may occur.

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[5] " Women's Contributions in the Field of Invention." *Bulletin of the Women's Bureau,* No. 26. U. S. Department of Labor, Washington, D. C., 1923, p. 17.

Invention is a social process. — In early stages of human history most inventions were of the random-experiment type; even when science began to be developed the exceptional man for a long time played a vital part in the inventive process. Both of these are still important, but under modern conditions of competitive industry, and the universal spread of scientific knowledge the individual counts for less and the group for more.

The exceptional mind of the great inventor is important in focusing social forces and effecting a combination of such a character as to give a new direction to social and industrial progress. But, after all, the individual does not rise much above the level of the group in which he is placed, and he utilizes a common fund of knowledge and experience which constitutes the social heritage. The industrial inventor can avail himself of the labors of all who have preceded him and can build upon them. He can acquire their knowledge and avoid their mistakes. Invention is thus a social process which proceeds by summation, in which the individual makes but a small addition to the whole. In the field of invention, as in no other, one man's work depends upon another's. The technical apparatus which constitutes the equipment of modern industry is by no means the product solely of a few outstanding genuises, but is in great part the result of small increments of invention contributed by thousands of humble workers.[7]

Moreover, each new invention changes the environment under which the next generation works. Environment determines in large measure the aptitudes and interests of the people living in it. If, by reason of an invention, say of the steam engine, a new direction is given to men's thought and a new industrial and social milieu is provided, less credit can on the whole be given to the originality of those who improve on the work of the pioneers.

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[6] E. C. Hayes, *Introduction to Sociology*, N. Y. 1915.

[7] Speaking of tool making among primitive people Professor E. B. Tylor (*Anthropology*, p. 183) says, " Looking at the various sorts of implements, we see that they were not invented all at once by sudden flashes of genius, but evolved or one might almost say grown, by small successive changes."

Environment rather than the man must be held responsible. Increasingly therefore the individual becomes submerged in society.

If genius be defined, in the words of Goethe, as " the capacity for taking infinite pains," then the explanation of genius becomes simple. The genius is a man who stands in the midst of innumerable social and material forces, and who succeeds in forming a new combination which proves useful in gratifying man's wants. But as many of the forces or elements which he recombines were themselves discovered or invented by his predecessors, he cannot claim all the credit.

Modern invention is organized. — The more highly any line of mechanical appliances is developed, the more likelihood there is that subsequent improvements will be in details rather than in a revolutionary new discovery. It is also probable that invention will follow the lines already marked out rather than strike off in an unchartered field. Each invention stimulates others, and the new ones are likely to be related to those which have preceded. Thus, the early inventions of Hargreaves, Arkwright, Crompton, and Cartwright were all connected with textile machinery; the invention of the telegraph, the telephone, and the radio each unleashed a multitude of related inventions. Sometimes inventions in one field open new opportunities in another; thus the development of preventive medicine made possible the achievements of engineering science in the building of the Panama Canal.

In the past invention has frequently been fortuitous, or at least very irregular. Since the beginning of the nineteenth century, however, industry has become increasingly dependent upon science, and business is now beginning to make deliberate and conscious attempts to organize and direct inventive effort. It is no longer willing to depend upon occasional and fortuitous inspirations of genius. This takes the form of organizing research departments in the plants, or of aiding the establishment of research and of experiment stations in the universities. Academic research pushes the bounds of human knowledge a little further, but confines itself to the purely scientific aspects of a problem. Applied research endeavors to apply this knowledge to some immediately useful purpose. The one is the foundation and the other the superstructure in modern industry. It cannot be said that research in itself will produce new inventions, but it should certainly facilitate them. The inventions of the man of genius are apparently little affected by this systematized and organized work of research. But thousands of small improvements, which usually render the first revolutionary idea more useful, are made by trained industrial technologists in the course of their ordinary duties. Work of this character is greatly aided by research.

As the work of research, both pure and applied, and perhaps of invention, tends to be better organized and directed to the solution of particular industrial problems, the results may be considered a social product. And, since a steadily increasing number of inventions is utilized in modern industrial processes, it may more and more truly be said that modern industry is a social heritage.

Growing dependence on technicians. — Modern industry is the process of transforming raw materials into finished products for the satisfaction of human needs. This process involves the use of many machines and the employment of labor of all kinds, skilled and unskilled, administrative and technological. With every addition to the mechanical appliances of modern industry the dependence upon the technician, the engineer, and the chemist, becomes greater. One of the mistakes made by the Bolsheviki, in the first excesses of the Russian Revolution of November, 1917, was the dispersion if not the destruction of this group of workers, and the slow industrial recovery of Russia since then is due, in part at least, to the lack of technically trained men.

If a people is to advance industrially it is not enough to utilize efficiently the existing machines; new knowledge must be developed and applied. Improvements in industry usually result from invention and discovery, which shorten processes, reduce costs, or improve quality. A higher standard of living or the achievement of greater leisure are the best results of a more efficient industrial technique. These are, or should be, the contributions of machine industry to modern civilization.

The inventions of the nineteenth century. — The great inventions which ushered in modern machinery and technique began in the latter part of the eighteenth century, and the greatest of all was the steam engine. So important was this that the nineteenth century has often been called the age of steam. But before the century was half over a new series of electrical inventions was made, which partially supplanted the use of steam and has caused this second period to be called the age of electricity.

Among the important inventions which characterized the century may be named the electric telegraph, the dynamo-electric machine, the electric light, and the telephone. Equally transforming in its effects was the invention of the modern processes of making steel. This, together with the utilization of heat and power, especially in the steam engine, and of electricity for purposes of communication and power, have completely transformed methods of industry and enormously increased the production of wealth.

In order to appreciate the contributions which invention has made in the nineteenth century to industry, a comparison of conditions in 1900 with those in 1800 will be instructive. For this purpose a somewhat extended quotation may be made: [8]

" Reverse the wheels of progress, and let us make a quick run of one hundred years into the past, and what are our experiences? . . . We are no longer gliding along in a luxurious palace car behind a magnificent locomotive, traveling on steel rails, at sixty miles an hour, but we find ourselves nearing the beginning of the nineteenth century in a rickety, rumbling, dusty stage-coach. . . . But railroads and steam-cars constitute only one of the stirring elements of modern civilization. As we make the backward run of one hundred years we have passed by many milestones of progress. . . . We quickly lose the telephone, phonograph, and graphophone. We no longer see the cable-cars or electric railways. The electric lights have gone out. The telegraph disappears. The sewing machine, reaper, and thresher have passed away, and so also have all india-rubber goods. We no longer see any photographs, photo-engravings, photo-lithographs, or snap-shot cameras. The wonderful octuple web perfecting printing press, printing, pasting, folding, and counting newspapers at the rate of 96,000 an hour, or 1600 per minute, shrinks at the beginning of the century into an insignificant prototype. We lose all planing and wood-working machinery, and with it the endless variety of sashes, doors, blinds, and furniture in unlimited variety. There are no gas-engines, no passenger elevators, no asphalt pavement, no steam fire engines, no triple-expansion steam engine, no Giffard injector, no celluloid articles, no barbed wire fences, no time-locks for safes, no self-binding harvesters, no oil nor gas wells, no ice machines nor cold storage. We lose air engines, stem-winding watches, cash registers and cash-carriers, the great suspension bridges, and tunnels, the Suez Canal, iron frame buildings, monitors and heavy ironclads, revolvers, torpedoes, magazine guns and Gatling guns, linotype machines, all practical typewriters, all pasteurizing, knowledge of microbes or disease germs, and sanitary plumbing, water-gas, soda water fountains, air brakes, coal-tar dyes and medicines, nitro-glycerine, dynamite and guncotton, dynamo electric machines, aluminum ware, electric locomotives, Bessemer steel with its wonderful developments, ocean cables, enameled iron ware, Welsbach gas burner, electric storage batteries, the cigarette machine, hydraulic dredges, the roller mills, middlings purifiers and patent-process flour, tin can machines, car couplings, compressed air drills, sleeping cars, the dynamite gun, the McKay shoe machine, the circular knitting machine, the Jacquard loom, wood pulp for paper, fire alarms, the use of anæsthetics in surgery, oleomargarine, street sweepers, Artesian wells, friction matches, steam hammers, electro-plating, nail machines, false teeth, artificial limbs and eyes, the spectroscope, the kinetoscope or moving pictures, acetylene gas, X-ray apparatus, horseless carriages, and — but, enough! the reader exclaims, and indeed it is not pleasant to contemplate the loss."

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[8] Byrn, E. S., *The Progress of Invention in the Nineteenth Century* (N. Y., 1900), pp. 4–6.

Long as this list is, it takes no account of the many marvelous inventions of the twentieth century, for it stops with the year 1900. Since then have been developed the automobile and tractor, the submarine and airplane, the radio and the transatlantic telephone. The agencies of war were completely revolutionized by the inventions made between 1914 and 1918, and those of many peacetime industries have been only a little less profoundly affected. As illustrations may be mentioned rayon or artificial silk, fixation of atmospheric nitrogen, and quartz glass, to mention only a few.

Some typical inventions: the sewing machine. — In 1846 the sewing machine, so-called, was invented by Elias Howe. This was not a particularly brilliant invention, but it was socially very important, for it immensely lightened the household labors of women in making clothing, and was later applied in the sewing of shoes, leather goods, carpets, and numerous other articles.

Although Howe is credited, and properly so, with the invention of the sewing machine, other inventors had long been working on the problem. In 1790 Thomas Saint patented in England a chain-stitch sewing machine, but Saint was ahead of his time and his invention was forgotten. In 1830 a Frenchman named Thimonnier invented a chain-stitch sewing machine, but the tailors feared it would deprive them of work and destroyed his machines. The first lock-stitch machine, embodying the essential principles of the modern sewing machine, seems to have been made by Walter Hunt in New York between 1832 and 1834, but Hunt never completed the working model nor took out a patent, and it is certain that Howe did not know of this effort when he invented his machine.

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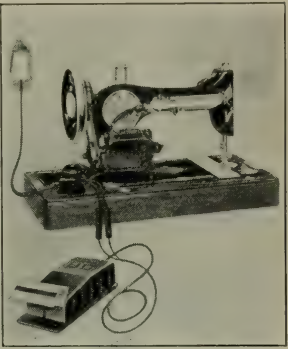
The First Singer, 1851

The story of the invention of the sewing machine by Howe is the familiar one of many inventions: the development of the idea in the mind of the inventor, struggles against poverty, discouragement, and failure while working it out, perseverance through all difficulties and unremitting toil until success was finally achieved. Elias Howe was born in 1819, near Worcester, Massachusetts, where his father had a small farm and lumber mill. Here he received a valuable though unsystematic training in the manifold labors of farming, household crafts, and his father's business. At the age of sixteen he went to work in a factory manufacturing cotton machines in Lowell, and after this was closed by the panic of 1837 he found a position in Cambridge with Ari Davis, a manufacturer, and repairer of chronometers, surveying instruments, and similar appliances. It was in this congenial atmosphere that Howe, in 1843, began to build his sewing machine, which he completed a year later.

Howe's first model was a crude affair. A curved eye-pointed needle, such as lacemakers had long used, was fastened at the end of a lever which had a motion like that of a pick-ax; when the needle was driven through the cloth a shuttle carried a second thread through the loop of the first one, thus forming a lock stitch. A second, improved model formed the basis of Howe's patent, which was issued in 1846. Subsequent inventions, of which about 7000 have been patented in the United States alone, have greatly improved the sewing machine, but the original features which Howe patented still form the basis of the modern machine. Although met at first with derision and objections, the sewing machine after a decade found general adoption and brought to its inventor a fortune. The reward which the inventor reaped, however, was trifling compared with the benefits which it has brought to society.

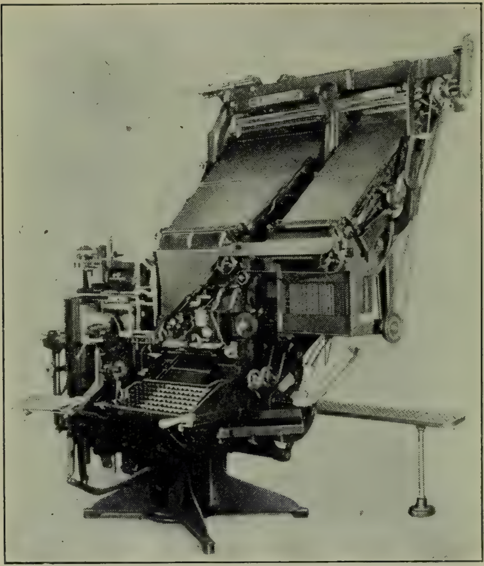


THE SINGER PORTABLE ELECTRIC, 1926

The linotype. — The most revolutionary and important invention in the art of printing since John Gutenberg devised types moved by hand was the invention in 1884 of the linotype by Mergenthaler. This was a brilliant and original conception, far surpassing in genius the sewing machine. It resembles the sewing machine, however, in its social usefulness and its revolutionary influence upon the industry which it affected.

Ottomar Mergenthaler was born in 1854 near Stuttgart, Germany, the son of a poor school teacher, and at the age of fourteen was apprenticed to a watchmaker. When eighteen years old he emigrated to the United States, where he found work with the son of his former employer, a maker of electrical instruments in Washington, D. C. This city was then the focus for all important inventions and in the Hahl shop were constructed many models, upon which young Mergenthaler worked. Among other machines was a lithographic writing machine, which proved a failure, but the work upon which directed Mergenthaler's thoughts to a typesetting machine.

The old-time compositor or typesetter used to stand before a wooden case containing about 150 compartments, each of which was filled with types representing different letters, numbers, punctuation marks, etc. In his left hand he held a " stick " or flat metal receiver for the type which he picked out of the appropriate compartments with his right hand. Each line must be justified, that is the words must be so spaced or apportioned that each line was the same length as every other line. After the type had been set up and the printing finished the printer had finally to distribute the type again to the various compartments.



The Linotype Machine

After eight years of experimentation Mergenthaler produced his first machine in 1884, and patented it in 1885. He was continually making improvements, however, and not until 1886 was practical use made of the new invention, when it was introduced into the printing office of the *New York Tribune*. It was completely reorganized and improved in 1890.

The main features in Mergenthaler's linotype are the setting of the type by manipulating the keyboard, which resembles that of a typewriter. Pressure on a lettered key brings down from a magazine or compartment a little brass plate called a matrix, bearing the corresponding letter, which are automatically arranged in a line. Justification, or spacing, is also performed automatically. When a line is complete molten type metal is forced into the groove formed by the depressed letters, and a single slug is produced for each line of type. The matrices are then automatically distributed to their respective magazines.

It is difficult to estimate the value of this invention, but it has revolutionized the printer's trade, and, together with machine-made paper, has made possible the cheap newspaper and magazine of the present time.

SUGGESTIVE QUESTIONS

1. Have you ever devised a means for lessening the burden of some task? If so, describe it.
2. Give examples of unused resources in the animal, vegetable, and mineral kingdom.
3. Just what is an invention? Are these inventions: a new recipe for a cake; the Einstein theory of relativity; using a plaster cast on a broken limb?
4. Name some inventions for which there is an urgent need.
5. What is a genius? Are you acquainted with one?
6. It was once said that school teachers are continually devising contrivances to assist them in their work. What would likely be the nature of these contrivances?
7. Find out to what extent the early textile machines found favor with the working people. How do you account for their attitude? Do you know of any similar examples to-day?
8. Should a person be called lazy who is always trying to find an easier way to accomplish some task?
9. If you made an invention, how could you obtain a patent on it?
10. When Crusoe was cast ashore on his lonely island, which do you think was the more important to him, his tools or his knowledge of industrial processes?
11. Give some illustrations of the saying, "Necessity is the mother of invention."
12. Do you believe that invention is the contribution of a genius, or that it is a social product?
13. Do you know of any industrial concern which employs inventors or research investigators?
14. Why is it that so frequently inventors have had to struggle with poverty, discouragement, and failure before they made a success of their invention? Illustrate by the experiences of Whitney, Goodyear, Morse, and others.
15. Write an account of one of the inventions listed on pages 378–379.

BIBLIOGRAPHICAL NOTE

Books on invention for the most part fall into two groups, those dealing with particular inventions, as the telegraph, or biographies of inventors. Of the two the latter are the more interesting and stimulating for the general reader. Such books as the *Autobiography of James*

Nasmyth (edited by Smiles, London, 1883), or Michael Pupin, *From Immigrant to Inventor* (New York, 1924), or the lives of Watt, Morse, Goodyear, Howe, Bell, Edison, and others, are full of inspiration and information.

The best book on invention in general, although rather disorderly in arrangement, is B. A. Fiske, *Invention: the Masterkey to Progress* (New York, 1921). Other good books are E. A. Byrn, *The Progress of Invention in the Nineteenth Century* (New York, 1900); A. P. M. Fleming and J. G. Pearce, *Research in Industry* (London, 1922); G. Iles, *Leading American Inventors* (New York, 1912); and F. W. Taussig, *Inventors and Money-makers* (New York, 1915). More popular and wholly non-technical are F. P. Bachman, *Great Inventors and their Inventions* (New York, 1918); R. Doubleday, *Stories of Inventors* (Garden City, 1915); S. E. Forman, *Stories of Useful Inventions* (New York, 1914); W. R. Hayward and G. W. Johnson, *The Story of Man's Work* (New York, 1925); and M. R. Parkman, *Conquests of Invention* (New York, 1921).

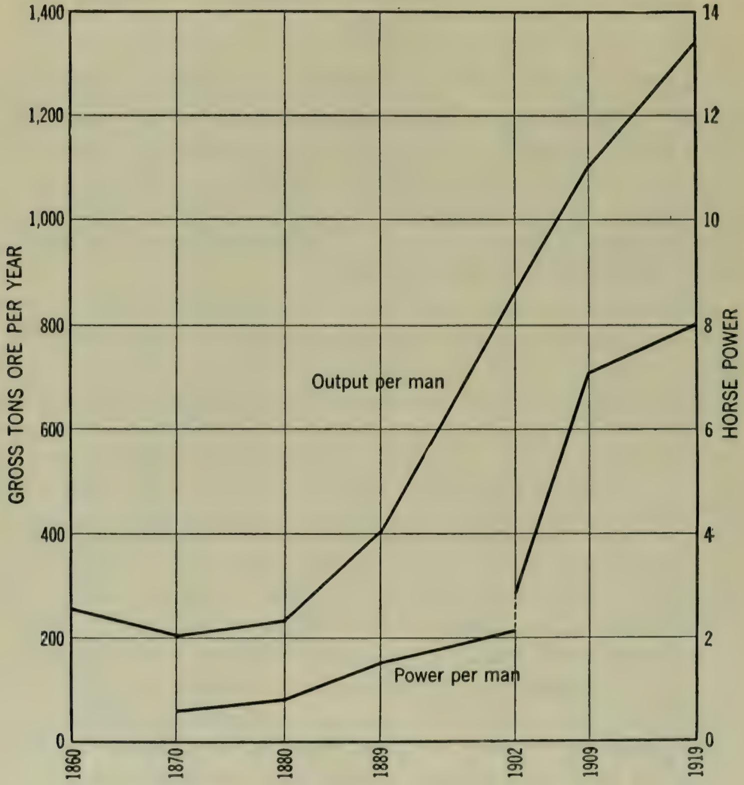
CHAPTER XXVII

POWER

What is power? — The term power, as it applies to the doing of work in the broadest sense, means the application of energy, either human, animal, or mechanical, as a moving or a propelling force. In this chapter it will, however, be used in a narrower sense, to include only non-human power, whether this be produced by animals, natural forces like wind or falling water, or by releasing the energy stored up in mineral fuels.

Power may be used either directly or indirectly. When a man lifts a stone or a horse pulls a plough, the force is applied directly. But most energy must be applied indirectly. The reason for this is that, although it is found in nature in large quantities, it is not in a form that is immediately available. Coal illustrates this principle. A piece of coal itself can exert no force whatever. But it has, stored within it, energy, which, if released, will exert great force. To release this energy which is contained within the coal so that it can be made to serve his needs, man has devised steam engines and other machines. By burning coal under a boiler which contains water, the energy of the coal is released in the form of heat. It warms the water in the boiler and turns it into steam, and this steam confined under pressure may be made to operate machinery. Or the steam may be made to operate a turbine which generates electric power. All fuels must be put through a similar process in order to obtain the energy which they contain. Instead of the fuel itself doing the work, it is first changed into some other form, and the energy, in this latter form, applied as a mechanical force by being transmitted by some mechanism to a point where the force is desired.

The importance of power. — Power is the fundamental factor in modern industry. The present industrial era has been characterized variously as a Coal Age, a Steel Age, and an Electrical Age. But the factor which characterizes it more than any other is the use of non-human power. All of these other characterizations may be combined into this one because they are all phases of it. And one may say that the factor which determines the place of a nation in the scale of present-day civilization is the extent to which it has subdued and brought under control the energy resources that are stored up in nature. This is an age of power machinery or me-



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Yearly Output of Iron Ore per Worker Employed at Iron Mines in the United States

Figures represent tons of ore produced regardless of grade, as reported by the Census, divided by the average number of wage-earners employed. It is known that the average grade has been decreasing since 1893, but not by so great ratio as the increased output per man here shown. Curves for power represent total installed primary horse power, divided by number of wage-earners. Prior to 1902, they include only steam power; after 1902, all primary power is included, and for 1902 both figures are shown. (From Louis I. Dublin's *Population Problems in the United States and Canada*. By permission.)

chanical power. This substitution of resource energy for human energy is the outstanding feature of the modern industrial world.

A comparison may serve to show the importance of power. The United States is the premier country in the use of mechanical power, and the people in this country enjoy the highest level of living conditions of any people in the world. That there is a correlation between these two conditions seems to be proved by the fact that both the wages and the product per worker are higher in the United States than in other countries. In the steel industry the American worker uses twice as much horse power in the form of power-driven machinery as does the British worker, and at the same time the tonnage output per worker in the United States is about double what it is in Great Britain; his wages are also double. The same relation exists in comparison with the Japanese worker, though still more to the disadvantage of the latter.

Sources of power. — The following list gives the world's power resources, both present and potential:

1. Human beings
2. Animals
3. Natural forces
    a. Wind
    b. Sun
    c. Volcanoes
    d. Geysers and hot springs
4. Water
    a. Tides
    b. Waves
    c. Streams
5. Fuels
    a. Coal
    b. Petroleum
    c. Natural gas
    d. Wood
    e. Vegetable by-products and waste

Human power. — This is the original source of power, and is still and always will be an important method of doing work. The use of machinery may lighten the work and make more plentiful the necessities and pleasures of life, but men are needed to make and tend the machines. There are also some kinds of work in which it would be impossible to use machines. The people in the tropics have had to depend upon hand labor to a large extent because the intense heat prevents the full utilization of beasts of burden, and moreover, so dulls the intellect of the people as to prevent the development of ingenuity to utilize some of the other sources. In countries where population is dense and resources scarce, handwork is customary. China, India, and Java are examples. The need for food and the poverty of the people prevent the use of methods that are found to be economical in the more sparsely settled and richer nations.

So long as a people depends upon human power alone for the production of wealth they cannot hope to progress industrially. It is only when they economize human labor and supplement it with the power derived from other sources that they can advance.

Animal power. — The first source of power other than human muscles of which man availed himself was animal power. Since no animals have been domesticated within historic times, it is evident that this form of power has been in use for a long period. And in spite of all the improvements in machinery and mechanical devices, the labor of domesticated animals still furnishes most of the power used in agriculture and for pulling implements and transporting goods in backward and undeveloped regions of the world. Even in the United States where mechanical farm machinery has been most widely introduced, there were on the farms in 1920 about 26,000,000 horses and mules, which represent a potential power nearly equivalent to that used in manufacturing — 29,500,000 in 1919. With the aid of this non-human power, both animal and mechanical, the production on the farms has been greatly increased; between 1870 and 1920, for instance, the production of the three leading crops — corn, wheat, and cotton — more than trebled though agricultural population less than doubled. The average farm worker used in 1920 about five times as much machinery as his father or grandfather did in 1870.

The chief animals used as beasts of burden are the horse, mule, donkey, ox, dog, elephant, camel, llama, buffalo, yak, and reindeer. Each one is adapted to certain types of work and to certain climatic conditions.

Natural forces: winds. — With the exception of wind power, the use of energy from natural forces is still in the developmental stage. Wind is one of the oldest sources of power and it has been used to operate ships, mills, pumps, and small railway cars. In China, many of the vehicles that are used for transporting goods are propelled by sail. Recently (1926) there sailed from Germany to New York a " rotor " ship, which was propelled by wind operating on large vertical cylinders or rotors, driven by small motors, and which used no sails. The rise of Holland as a world empire was due largely to the utilization of wind power on the land and on the sea. The chief employment of wind power in the United States is to pump water. But because it is not dependable, the gasoline motor has supplemented it to some extent in this employment.

Solar energy. — Compared with the energy of the sun's rays, which come to the earth in the form of light and heat, all other sources of power are insignificant, but as yet there has been invented no commercially practicable means of utilizing this energy. Experiments have been made with solar engines with converging mirrors, which gather and concentrate the rays of the sun on a single spot. The intense heat thus generated may be used to produce steam by which machinery may be propelled. The objection to such devices is that they are expensive to construct, and can be used only in regions where the sunshine can be depended upon continuously from day to day. Such regions are found only in the tropics or in desert areas, far from the present industrial centers, or where population is sparse. It has been estimated that the heat of the sun's rays which fall upon any two of the arid counties of Texas generate enough energy to propel all the machinery in the United States which is now moved by other forms of power.

Volcanoes and geysers. — The heat contained in volcanoes is a potential source of energy, but as yet very little use has been made of it. During the World War, however, an Italian engineer succeeded in developing and utilizing power from volcanic heat; near Volterra, subterranean steam was brought to the surface in pipes and made to generate electric power of some 10,000 h.p., which was transmitted to the neighboring cities of Leghorn, Florence, and Pisa. Geysers and hot springs could also be utilized, and in one instance at least, in California, steam has been obtained from this source under sufficient pressure to run engines.

Both volcanoes and geysers are usually situated in such rough and inaccessible locations, and the amount of power obtainable would probably be so small, that the utilization of the power from these sources is unlikely so long as coal and petroleum can be employed.

Water: tides and waves. — More important than any of the natural forces thus far described is water. There are three ways in which water generates power: by the rise and fall of the tides, by the action of the waves, and by the force of running or falling water in streams.

Tide mills have been constructed at certain strategic points to take advantage of the force exerted by the tides, and recently renewed interest has developed in their possible utilization as a source of electric power. A tide power plant is projected at Passamaquoddy Bay, Maine, by which the water is to be impounded at high tide in huge basins formed by the erection of dams, and from which it will later fall so as to turn turbines. Another plant, erected at Rockland, Maine, uses a similar system to compress air, which is then used as a form of power. A somewhat different principle is utilized in a tide plant in the Severn River in England, where turbines are set in the body of a dam built across the mouth of the river. In all these cases the difference in level between high and low tide is not less than 30 feet, so that an enormous amount of power at low head is available if it can only be properly harnessed.

It has also been thought that the force of the waves of the ocean might be utilized to generate power. Experiments have been made with wave motors, but as yet with little success.

Water power. — One of the first important sources of mechanical power, whereby a considerable amount of energy could be concentrated in one place, was the force of falling water, either over a natural falls or at an artificial dam, on a specially constructed wheel. A primitive type of water wheel was made of two great parallel wheels which were joined together at the circumference by broad boards or paddles so set that the falling water struck them with full force, thus turning the wheel. Sometimes a single wheel was used and the paddles extended as radii out to the circumference, or buckets were used in place of paddles. The wheel was connected by shafts and gears with the machine to be operated, which was thus set in motion when the water wheel revolved.

Mills utilizing water power obtained in this direct fashion were long used for grinding grain or pumping water, and even to-day some large manufacturing plants favorably situated with respect to water power utilize this source of energy by means of water turbines. The chief industries utilizing it, either directly or in the form of hydro-electric power, are, in the order of their importance: transportation, pulp and paper mills, textile establishments, flour and grist mills, and lumber mills.

The early textile mills of Lancashire and New England owed their location to the excellent water power which exists in both these regions. Later, coal threatened to supplant, and did largely encroach upon, water power; but since about 1890, due to the generation of hydro-electric power, the pendulum has been swinging in the direction of water power again.

Requirements for abundant water power. — For the best development of water power resources in any region there must be (1) abundant precipitation, (2) a uniform flow of water, and (3) a slope sufficient to provide a good head of water.

The chief factor affecting water power is some form of natural storage. Dams can be built, but they are expensive. The best natural reservoirs are lakes. Then come in order of importance snowfields and glaciers, swamps and marshes, and forests. All of these store up water and permit it to flow gradually into the streams. A uniform supply of water is important in maintaining operation in a plant using water power. Operations can be conducted on a scale equal to the amount of power developed when a stream is at its minimum flow. If a plant were constructed to utilize all of the power when a stream was at its maximum flow, a great deal of equipment would be idle when the stream was low. In a stream, such as the St. Lawrence or the Niagara, originating in a lake, the flow of water is fairly uniform throughout the year. Otherwise there may be and generally are great fluctuations in volume.

Water power areas of the United States. — The water power resources of the United States are well distributed and fortunately they exist in large quantity in those regions that are destitute of coal. There are three regions where water power resources are abundant: (1) the northeastern states, (2) the southeastern states, and (3) the western states. The first of these regions has the greatest development and the best conditions for the utilization of water power but its potential resources are less than in the other two regions. There are a rough topography, many natural lakes which serve as reservoirs, and abundant and well-distributed precipitation. The northeastern states utilize a great deal of water power because (1) manufactures were established there before coal was used; (2) they have no coal, and transportation of the needed supplies is expensive; (3) the glacial topography is favorable; (4) they have an abundant, uniform rainfall; and (5) the dense population provides a labor supply and a market. Because of these factors, 86 per cent of the maximum potential water power resources of New England have been developed.

The southeastern states have more water power available but conditions for development are not so good as in New England. These states have abundant rainfall, but it is not so well distributed nor so uniform as in the northeastern states. Neither are natural storage facilities so plentiful in the South. Only 32 per cent of the maximum amount of available power has been developed in this region. This is because of the backwardness of this region in the development of manufactures.

The western states of the Rocky Mountain and Pacific Coast regions surpass all other parts of the country in water power resources. Of these states Washington and Oregon are most important. In general, because of the lack of coal and the enormous water resources, this region is admirably adapted for a great future development of hydro-electric power. At present only a little over 7 per cent of the maximum amount available has been developed. The region is rough, providing a good head of water, and there are many lakes and snowfields which provide storage facilities, but in some sections the rainfall is not uniform.

Regional distribution of water power. — The minimum water power energy of the United States — that available from the natural flow of the streams — is estimated at about 25,000,000 horse power; the maximum — that available from both natural and artificial storage facilities — at double that amount. These amounts are divided among the three regions as follows:

	Min.	*Max.*
Northeastern states	2,225,000 h.p.	4,093,000 h.p.
Southeastern states	2,346,000	4,257,000
Western states	20,194,000	39,209,000

The western states have over four-fifths of the total water power resources of the nation.

The utilization of water power. — The following table shows the kinds of power used in the manufacturing industries of the United States.

Amount of Horse Power used in Manufactures [1]

Kinds	1909	1914	1919	1923
Water power	1,822,888	1,826,413	1,765,131	1,802,805
Steam engines	14,228,632	15,591,171	17,036,201	16,695,493
Internal combustion engines	751,186	988,591	1,241,829	1,230,302
Rented electric power	1,749,031	3,884,724	9,284,499	13,365,628
Total	18,551,737	22,290,899	29,327,660	33,094,228
H.p. per wage earner	2.8	2.9	3.2	4.3

A comparison of the two tables presented above shows that only a fraction of our potential water power resources is being utilized — less than two million horse power used directly out of a total of from 25 to 48 million. It was estimated in 1921 by the United States Geological Survey that existing water plants in this country had a capacity of 7,348,197 horse power. Even if this were all utilized it would amount to only between 15 and 30 per cent of the total. Actually only about 10 per cent of the potential supply is being utilized. The situation in the United States reflects fairly accurately the world situation. The World Conference on Power, which met in London in 1924, estimated the total potential water power in the world at approximately 293,000,000 horse power, of which about one-tenth has been developed. The countries other than the United States which make most extensive use of water power are Switzerland, Norway, Sweden, Italy, France, Germany, Austria, and Hungary.

Some large power developments. — The greatest engineering feats in connection with the utilization of water power have probably been performed at Niagara. It is impossible even to mention these, but reference may be made to two notable discharge tunnels driven 7,000 and 2,000 feet respectively through the rock. The latter makes use of a fall of over 200 feet, so that the water, emerging at the bottom at an enormous pressure, will ultimately furnish power for ten units of water turbines of 40,000 electrical horse power each.

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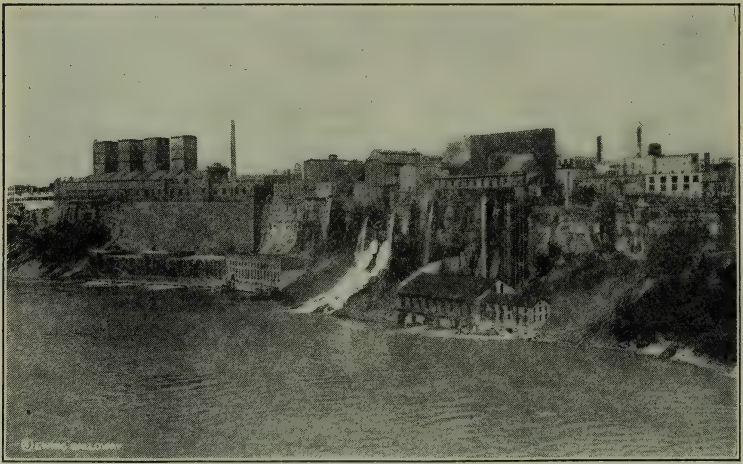
[1] Compiled from the census reports.

Another large undertaking is at Keokuk, Iowa, where the Mississippi River has been dammed and 200,000 horse power of energy developed. At present this energy is transported to St. Louis where it is cheaper than the electrical energy made in St. Louis from coal. Ultimately, the company controlling this plant hopes to distribute electricity over an area of about 500 miles radius.



Power Development at Niagara Falls

The illustration shows the great power houses of the Hydraulic Power Company. Other power developments are built on the Canadian side.

A new project, not yet finished, is at Muscle Shoals where the Tennessee River has been dammed. Nitrates were made here for munitions during the War, but it is planned now to utilize this power primarily to supply electrical energy for the surrounding area.

Fuels. — Fuels, and especially coal, have furnished the basis for our modern industrial development. Without coal, the large manufacturing and transportation systems of the advanced industrial countries would not exist. The reason for the importance of fuels is because of certain advantages which they possess over other sources of power. Human beings and animals are weak when compared with fuel-burning machines. The power developed by human beings or animals cannot be concentrated and applied at a single point or in large amount as can the energy of coal or oil. None of the other sources are so dependable as fuels; these can be obtained in any desired amount and used continuously in the machine which generates the power. Then the mineral fuels are generally located where they can be utilized to the best advantage, and even if they are not they can be transported to the points where they are needed. It has been suggested that the coal might be used in the vicinity of the coal mines, if these are inconveniently located, to generate electric power, and that this power could then be cheaply and easily transmitted.

The other fuels are generally used for heating purposes, as wood and natural gas and vegetable wastes, or as raw materials in further manufacturing processes. Coal and petroleum serve in both these capacities as well as for generating power.

Power and manufacturing. — It is not enough for a people to have resources of coal or petroleum; they must possess also the industry and ingenuity to utilize these resources. Fortunately, the chief power minerals — coal and petroleum — have, for the most part, been found in the temperate regions where the people possess the qualities mentioned. The United States, Great Britain, and Germany possess or control large deposits of these mineral fuels, and have at the same time shown the most rapid industrial development. The possession of these resources has undoubtedly been an important factor in this progress, but even more vital has been the character of the people themselves.

Other countries have deposits of these minerals, but as yet they have been developed only by people from the more advanced nations, showing that industrial development is dependent not so much upon the possession of certain natural resources as upon the qualities of the workers. If such a people lack any of these important resources, their ability leads them to develop substitutes or to go into other parts of the world and obtain them, either by commerce or conquest.

One of the striking things shown in the table given above is the rapid increase in the United States of the non-human power which supplements the muscular energies of the workers in our manufacturing industries. This grew from 2.1 horse power per wage earner in 1899 to 4.3 in 1923. As a result of this expansion the worker in 1923, although working fewer hours per day than his predecessor in 1899, was able to turn out a larger product. At the same time the worker's position has been altered from that of a manual laborer to that of a director and controller of the iron slaves placed at his command. If each horse power represents ten men, the 4.3 horse power provided for each wage earner is the equivalent of 43 men.

Steam power. — The era of steam power was ushered in by Watt's invention of the steam engine. [2] By this invention power was freed from geographical limitations. Water power had to be used at the place where it existed, but coal could be carried to the point where it might be used most advantageously in the generation of steam. Steam is generated by burning coal or some other fuel under a boiler which contains water. As the water is heated it changes to steam which can be forced under pressure to propel machinery.

A reference to the table given above (p. 393) shows that in 1909 the steam engine contributed almost 80 per cent of the power used in the manufacturing industries of the United States. Gasoline engines and electric motors have shown a much more rapid development since that date, but in 1923 steam still contributed over half the power. As has been already stated the people in the United States make a larger use of power from these sources than do those of any other country. In the fifty years ending in 1926, the production of coal in this country increased almost 20 times and that of petroleum over 80 times; but during the same period the population barely trebled. Coal is used primarily in the development of power for factories and railroads, and petroleum — or its derivative gasoline — for motor vehicles; for this reason the latter does not bulk very large in the table for manufactures only.

The steam turbine. — The explanation of the relative falling behind in the use of steam is to be found in the lack of efficiency of the piston steam engine itself. Of the heat energy released by burning coal under a locomotive boiler only about 8 per cent is recovered in motive power and even in the best stationary engines less than 20 per cent of the potential energy in the coal is made available. Improvements have been made in the boilers and the furnaces, and by the introduction of automatic stokers, but the piston engine still remains a relatively wasteful machine. The steam turbine, in which the pressure of the steam acts upon blades rather than upon the piston, is much more efficient, and is gradually supplanting the piston engine for large establishments. One type of steam turbine, used to generate electricity, is described in the following extract: [3]

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[2] Matthew Boulton, member of the firm of Boulton & Watt, manufacturers of steam engines, is said to have engaged in the following conversation with George the Third: " In what business are you engaged? " asked the king. " I am engaged, your Majesty," said Boulton, " in the production of a commodity which is the desire of kings." " And what is that? What is that? " " Power, your Majesty," replied Boulton.

" A steam turbine of the Parsons type consists of a long closed horizontal drum mounted on a shaft in a strong casing, through the ends of which the shaft passes. The annular clearance space between the drum and casing increases by stages, as the latter is " stepped," and this space is filled by rows of curved blades, alternate rows being attached to the drum, and those between them to the casing. The tips of the drum blades just do not touch the casing; while those of the casing just clear the drum and the other blades. In a large turbine there may be some hundreds of thousands of blades, of lengths ranging from an inch to over a foot. Steam is admitted at the smaller end of the casing and threads its way through the many rows of guide and moving blades, every one of the last getting a sideways push which is transmitted through drum and shaft to the generator. After expanding greatly the steam escapes to the condenser either direct or after doing further duty in another turbine. A turbine is so well balanced and revolves a thousand times or more per minute, so smoothly, that a coin stood on edge on the casing is not upset."

The largest steam turbine in the world is now (1926) being built at the Waterside Station of the New York Edison Company. It will require 30 tons of coal an hour, which it will convert into 80,000 h.p. of electrical energy for the light and power needs of the city. Estimating that each horse power equals the power of ten men, it would require 800,000 men to develop this amount of power.

Internal combustion engines. — This is a name applied to engines using natural gas, petroleum, gasoline, kerosene, or alcohol. The fuel is introduced in a gaseous form or in liquid form at very high pressure into the engine cylinder, where it is mixed with air in the proper proportions to form an explosive mixture. It is ignited by a spark within the cylinder of the engine, and the pressure resulting from the explosion forces the piston into motion, which in turn generates the power to run the motor or machine.

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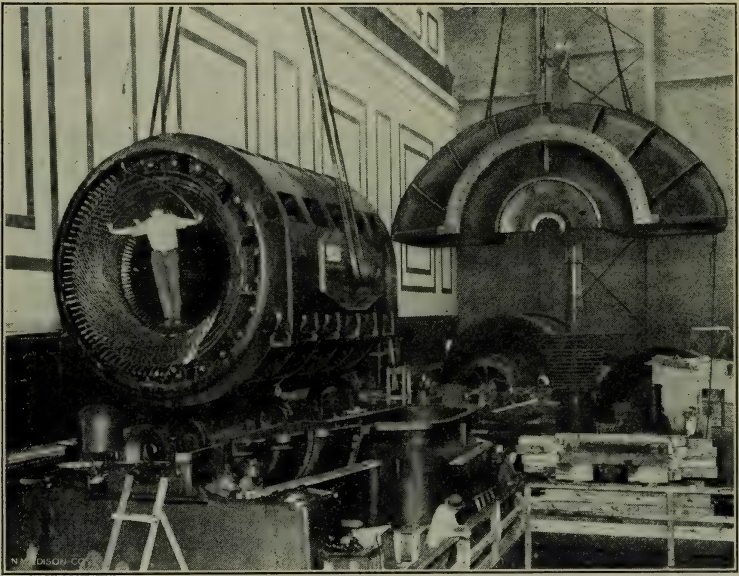
[3] J. A. Thomson (Ed.), *The Outline of Science* (New York, 1922), Vol. III, p. 813.



INSTALLING A GENERATOR

This is the largest plant of its kind in the world. It is located at the Waterside Station of the New York Edison Company.

The internal combustion engine has had a very rapid development, but its greatest application has been in the automobile industry, whose growth is in large part due to the invention and improvement of this source of power. In industry it ranks last as a source of power, though it is largely used for domestic and agricultural machinery. It has the advantages of instant availability, of availability in small units, movability, compact size, economical and efficient utilization of fuel, and cleanliness. Some of these points may be illustrated by a comparison of a Diesel engine burning heavy oil injected at high pressure and a steam engine burning coal, of identical power capacity.[4]

[4] De la Tramerge: *The World Struggle for Oil,* p. 15.

Item	*Diesel Engine*	*Steam Engine*
Horse power	21,000	21,000
Weight of engine and accessories	1,000 T.	3,400 T.
Space required	5,300 cu. m.	10,000 cu. m.
Daily consumption	100 T.	360 T.
Consumption for voyage of 15 days	1,500 T.	5,400 T.
Bunker space for voyage of 15 days	1,700 cu. m.	7,000 cu. m.
Total space required for engine and fuel	7,000 cu. m.	17,000 cu. m.

Electric power. — Thus far only primary power, or that derived at first hand from the sources of energy, has been discussed. Now we turn to secondary power, or that derived from one of the primary sources. Of this the most striking example is electricity. A bolt of lightning might be regarded, from a human standpoint, as primary power, but the electrical energy which lights our houses, runs our street cars, or drives the machinery in an industrial plant, has been derived from a wind mill, a steam engine, a water turbine, or other source of primary power. Electricity is simply a means or a method of applying primary power; an agency, and not itself a source of power. In discussing the advantages of electricity, this fact must always be borne in mind.

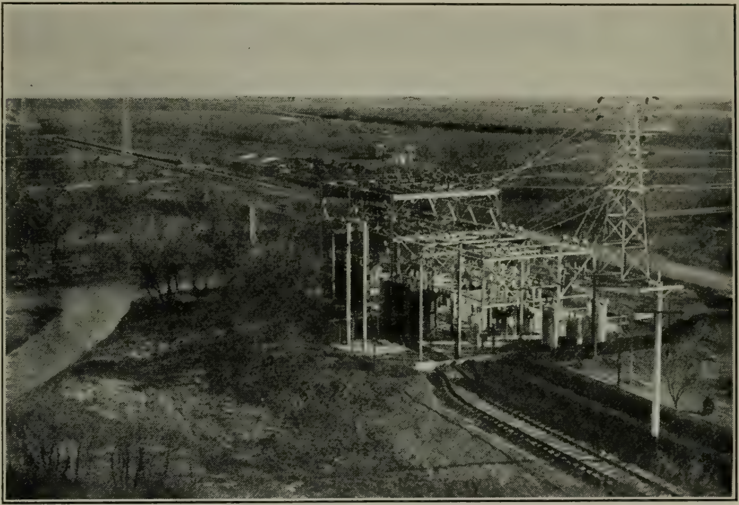
The nineteenth century was the age of steam, but the twentieth century seems destined to be the age of electricity. In 1890 electricity had scarcely more than made its début; but by 1900 it was already supreme in lighting and in urban transportation, and had effected an entrance into various industries. The transmission of electric power, a discovery of the closing years of the nineteenth century, may be compared as to importance with the invention of the steam engine at the end of the eighteenth century.

Reference to the table on page 393 will show the enormous strides made since 1909 in the utilization of electricity in manufacturing. A similar movement has been going on in transportation and in almost every other phase of industry. In factories the steam engine and the mechanical transmission of steam power by shafting and belts is being displaced by electric motors or rented current driving separate machines or groups of machines. Trains are drawn by electric locomotives; coal is cut, hauled, and hoisted by electricity; steel is made in electric furnaces capable of producing temperatures up to 6000° F.; and the electric arc will weld all manner of metals and alloys. Electric magnets are made, powerful enough to lift ten tons of scrap iron, and delicate enough to extract a sliver of steel from a workman's eye. We cook, do our laundry work, light our houses, send our messages, and get our entertainment over the radio by electricity.

Advantages of electricity. — Electrical power possesses many advantages over other forms of power. (1) It can be transported for much longer distances after it has been generated. This makes it possible to generate it at a central point and distribute it by transmission lines over a wide area. It is thus made available in the places most convenient for its use, as in large cities or near the sources of raw materials. (2) Electricity, because it is developed secondary power, is more efficient than primary forms of energy. An electric locomotive of a given number of horse power can haul a much heavier train than a steam locomotive of a like number of horse power. Neither does so much power have to be consumed in " getting up steam," and in making stops and starts. (3) The convenience attached to electricity is another point in its favor. It is always ready to be used, awaiting only the turn of a small switch, which will give all the power that is desired. (4) It is available in units of any size, for running a small motor for an electric fan or sewing machine or for a great central lighting plant. This makes it adaptable for certain types of industry, where it is desirable to attach individual motors to single machines, as in the manufacture of clothing. (5) A final advantage is the possibility of deriving electric power, not only from all the mineral fuels and other sources of power already mentioned, but also from other sources now going to waste. Thus, the energy in the waste gases from a blast furnace or smelting plant can be converted into electric power, as much as 400 h.p. being available from a single furnace.

Giant power. — This is the latest development in the field of supplying power to industry and it promises to assume large proportions within the next few years. The movement has arisen largely because of the desire to make more efficient and to conserve the existing power resources.

The essence of giant power is the central generation of power to be distributed in the form of electricity over wide areas and the interconnection of the different lines or systems, making possible the pooling of the power resources of the entire region. The ultimate objective is the conversion of all primary power resources into electricity at the point of their location and the development of regional systems which will in turn be federated into a national system. This means that all of the coal used would be converted into electricity at the mine; the petroleum used as fuel would be burned at the oil well; and the water power resources would be developed at the waterfalls or other points where energy is obtainable. But in a super-power system in the United States coal would still be the most important source of electrical energy, just as it is under the present organization of our power systems.



Outdoor Substation

Super-power transmission of the West Texas Utilities Company at Abilene, Texas.

A step in the development of this program is the interconnection of the lines of a large number of the smaller plants as they now exist. The name " super-power " has been given to such a system of interconnected power plants.

The advantages of super-power. — A super-power system possesses many advantages over the present disconnected organization. The advocates of this system claim that the following benefits will result from its adoption. By the application of power production on a large scale economies would be effected and the cost be reduced. These economies would result in a conservation of our power resources, especially coal and petroleum. At present a large amount of coal is used merely to transport other coal to power stations, but if power were generated near the mines, and mass transmission of the energy, under high voltages and over great distances, were adopted, the fuel resources would be conserved. It would then be possible to utilize railway equipment for other services. Manufacturing industries could be decentralized and moved out of the congested areas of our overgrown cities. As less coal would be burned by industrial plants, the cities would be cleaner. If the cost of power were materially reduced by such a system, larger use of electricity could be expected in industry, on the farm, and in the household. This in turn would reduce the cost of production of other commodities. The general adoption of such a system would essentially alter many aspects of modern industry.

Some examples of interconnected power systems. — There are several examples of interconnected power systems in the United States. One of the largest is 1200 miles in length, extending from Albany, Oregon, to the Mexican border. Water, petroleum, natural gas, and lumber mill waste are used to generate the electricity. The chief source, however, is water, as coal is lacking in this region. Electricity is employed extensively on the Pacific coast. In California, 83 per cent of all homes have electric lights as compared with 35 per cent for the whole United States.

Another system is a continuous line, made by connecting different systems, between Minneapolis and Louisville. A third is in the southeastern states, with a line about 800 miles in length, and a fourth of about equal length is in the northeastern states.

Power problems. — The power problems of the nation are concerned with the conservation of our power resources both to make them last as long as possible and to prevent their price from becoming prohibitive. The latter is of most immediate concern. Cheap power is essential if the manufactures of our country are to keep in the race with those of other countries. Water power cannot be exhausted, but the other sources can. And with the gradual exhaustion of coal and the necessity for working more costly deposits, and going deeper into the ground after them, the question of adopting methods which will keep their price down is important. This will be brought about by better methods and machines for utilizing these products, so that a greater amount of efficiency will be obtained from a given supply. As yet steam raising machinery has a working efficiency of only about 16 per cent. Compare this with a working efficiency of 90 per cent for the machines which transform the available energy of water into power.

From the long time point of view, the problem is to make the supplies last as long as possible. This can be done by being careful in their extraction and by using a substitute whenever possible for those which are irreplaceable. This is important in the case of petroleum, because its supply is very limited and nothing has ever been discovered to replace it as a lubricant for machinery. With our large numbers of high powered, rapidly driven machines, this is a matter of prime importance. There is already a movement in this country to encourage people to use petroleum only for the most necessary purposes and in employments for which nothing else will serve equally well. The other answer to the question is to develop all of our water power resources.

The chief problem in the development of energy from water power is that of cost. The capital cost of a hydro-electric plant is so great as to make the expense of producing electricity by this method, except in highly favored regions, almost as great as by burning coal. The necessary investment of capital for such plants will consequently not be made until all the engineering problems have been satisfactorily solved. After all, the best guarantee of conservation of exhaustible resources and of wise utilization of others is through the development of the latent powers of the human intellect.

SUGGESTIVE QUESTIONS

1. Press down on a pair of scales with one of your hands and see how much force you exert.
2. What does the term " horse power " signify? How is it measured?
3. When horses are used to furnish the power for a threshing machine or a corn sheller, is the power applied directly or indirectly?
4. What products, which are now wasted, contain potential power?
5. In what countries is human power used most extensively? Describe the different tasks that are done by human beings in these countries.
6. Can you name any backward people who use a great deal of power?

7. Can you name any industrially developed people who do not use a great deal of power?

8. Name some kind of work for which it is impossible to use a machine.

9. Find out the climatic conditions and the type of work to which each type of draft animal is best adapted.

10. What would be the advantage of wind mills in the Great Plains region?

11. What is the nature of and the cause of the tides?

12. If the world's supplies of coal and petroleum should suddenly vanish, what countries would be most capable of continuing the manufacturing processes?

13. Find out how the different continents and countries rank regarding the potential water power resources.

14. Find out how the automatic stoker on a large locomotive or in an industrial plant is operated.

15. How will automobiles be operated when the petroleum supplies are exhausted?

16. Why do many railways employ electrical rather than steam power within large cities?

17. Describe more fully the power development at Niagara Falls, at Keokuk, at Muscle Shoals, or at other points.

18. Is the internal combustion engine, such as the gasoline motor of an automobile, an efficient power producer?

19. If man could harness power to drive machinery, would his work be limited only to pressing buttons and shifting gears? What work would man have to do?

BIBLIOGRAPHICAL NOTE

The best references on power resources are found in the bibliography in Chapter XV, on Mineral Fuels. Books on water power resources are given in the bibliography in Chapter XII, on Water and Waterways.

The best book on power technique is C. E. Lucke, *Power* (New York, 1911). It is condensed and understandable, but authoritative. Similar but more technical are A. H. Gibson, *Natural Sources of Energy* (New York, 1913) and D. M. Myers, *The Power Plant* (New York, 1922). An excellent and detailed work is the *Transactions of the First World Power Conference* (London, 1924, 5 volumes). A report of similar nature covering the state of Pennsylvania is the *Report of the Giant Power Survey Board* (Pittsburgh, 1925); W. S. Murray, *A Superpower System for the Region between Boston and Washington* (Washington, 1921), is similar but more inclusive. The best condensed but popular discussion of the advantages of super-power is G. E. Tripp, *Super-power as an Aid to Progress* (New York, 1924). A book dealing with conservation is J. B. C. Kershaw, *The Use of Low Grade and Waste Fuels for Power Generation* (New York, 1920). The standard authority on conservation is C. R.

Van Hise, *Conservation of Natural Resources in the United States* (New York, 1910). On electricity, J. A. Fleming, *Fifty Years of Electricity* (London, 1921), is interesting and useful. Other books of a general nature are C. R. Gibson, *Electricity of Today* (London, 1912) and G. Kapp, *Electricity* (New York, 1912). An old but good book of a technical nature is L. Bell, *Electrical Power Transmission* (New York, 1901).

CHAPTER XXVIII

LARGE SCALE PRODUCTION

What is large scale production? — There has been a steady tendency for the size of the producing unit in most lines of industry to increase, whether measured by the amount of capital used, the number of workers employed, or the volume of the products turned out. The manufacture of goods in great quantities in these expanded plants is called large scale production. This term must, however, be considered as relative. Operations in one industry, relatively small for it, might yet be of such magnitude as to be considered large when compared with those of another industry. The nature of the article manufactured, the technological methods of its production, and the extent and character of the demand for it will determine primarily the most economical size of the producing unit. That is to say, they will determine whether a particular industry lends itself best to large scale or to small scale operation.

The expansion in the size of the producing unit may be either horizontal or vertical. Some industrial plants grow by employing more men and more machines, by adding a wing to the factory, by increasing the volume of their output. They expand in size, but without changing their character. Examples of horizontal or lateral growth are to be found in every thriving industrial city. A few of the most successful become large scale enterprises.

Other industries expand vertically. Every manufacturing industry begins with a certain commodity as raw material, which it works up into a finished good. If now this industry pushes its operations down to the prior stage of producing and working up its raw material, and up to later stages of further refining or marketing its product, then its expansion is said to be vertical. An illustration of this would be a blast furnace, which reaches down so as to control the iron mines and ore ships, and then reaches up so as to control rolling mills, wire and nail mills, and possibly distributing agencies. Such a case is found in the United States

Steel Corporation or in the Ford Motor Company. Generally both kinds of expansion go on together, and the enterprises then have a mixed character.

Importance of large scale production. — The significance of the very large plant, as compared with the plant of moderate or small size, is clearly brought out in the census statistics. Those for 1919 are given in the following table:

ESTABLISHMENTS GROUPED BY VALUE OF PRODUCT
ALL INDUSTRIES 1919

Value of product	*Percentage of total number of establishments*	*Percentage of value of product to total*
$ 5,000– 100,000	79.6	7.5
100,000–1,000,000	16.9	14.4
1,000,000 or over	3.6	78.2

Although the group of smallest establishments — those with less than $100,000 annual output — comprised almost 80 per cent of the number, they turned out only 7.5 per cent of the products. On the other hand, the very large establishments, although making up only 3.6 per cent of the total number of establishments, had products whose value was almost 80 per cent of the total, or fourteen times as much as the vastly larger group of small establishments.

The same picture would be presented if, instead of value of products, the capital invested or the number of workers employed had been used as the basis of distribution.

Two conclusions seem to be justified from a study of this table. One is that the small scale industry still exists and that most of our industrial establishments are of this type. The other is that four fifths of the work of manufacturing is done in large establishments, and that the proportion is steadily growing larger. The explanation of both these facts must be sought in an analysis of the causes making for large scale production.

Why large scale production developed. — The size of manufacturing plants has gone through a process of evolution from the very small workshop to the immense establishments of the present day. In the early days of manufacturing, transportation was scarce and costly; so the market for a given product was local in nature and necessarily small. It could be served adequately by a small shop that could be equipped and operated with the capital at the command of some individual enterpriser.

But the means of transportation were gradually improved, first on water and then on the land; then both types progressed together. This extended the area over which goods could be marketed profitably. As this expansion of markets developed, the size of the manufacturing plants gradually increased.

Hand in hand with the improvements in methods of transportation went new developments in the technique of production. Inventions of new processes, of labor-saving machines, of cheaper methods of production, enabled the intelligent and progressive producer to expand his operations at the expense of his competitors.

With the growth in size of the producing unit there arose a need for more capital, which the original enterpriser could not always provide. Other persons to furnish capital and perhaps to contribute special skill in supervising the details of the growing business were needed, so one or possibly several partners were taken into the business. These processes of improvement and growth continued, both in transportation facilities and in methods of production, until the most economical size of the plant outgrew the facilities at the command of the few partners who operated it. Other means for obtaining capital were necessary, and to meet this need the corporate form of industry was introduced.

Conditions favoring large scale production. — These have been mentioned briefly in the preceding section, but they are important enough to merit a more detailed treatment. The most important influences in causing the development of large scale production are: (1) efficient transportation and communication, (2) the corporate form of business organization, and (3) improved technique in the processes of production.

Transportation and communication. — The development of cheap and rapid transportation and communication was the chief influence in making possible the manufacture of products in large factories in the early stages of the movement toward large scale production. A manufacturing plant can be only as large as the market for its product will permit. If it is larger than this, difficulties will be encountered in selling the product and there may be times when a portion of the plant will be forced to suspend operations. This means a loss in efficiency. At the beginning of the nineteenth century in the United States, factories were small. Land transportation was difficult, while the equipment for water transportation at the command of the people was small and not adapted to the carrying of goods for long distances. The cost of carrying products for a very long distance was great and it was cheaper to make most things in the immediate vicinity of their consumption. This area was necessarily small because of the poor transportation, and the sparseness of the population further restricted the market. An enterpriser could not afford then to start operations on even a medium sized scale.

A little later, when the steamship had come into use and short railways and canals had been built, it was possible to manufacture some products along the Atlantic seaboard and send them to the settlers along the coast and to those west of the Appalachian Mountains. This was true of the more valuable products whose bulk was not an important item in their transportation. But still the settlers had to make many products near the point where they were to be consumed.

Gradually the transportation routes were extended until they covered the whole country. Better equipment was made for hauling products over these routes, this applying also to ocean shipping. Quick transportation on land and water was made possible. Many products which previously enjoyed only a restricted market now had a national or even a world market. Among these were such products as wheat, cotton, wool, copper, and manufactured commodities in general; in fact all products which were in wide demand and would withstand storage for a long period of time without spoiling. The production of such products was thus made possible in those places where the conditions for doing so were most favorable. This has caused the localization or concentration of certain industries in those localities where the most efficient production could be attained.

In the case of some industries thus localized, other factors favored concentration in single plants or concerns under unified control. In these large scale production developed. Here the most important factor is the technical conditions of the industry. Of minor importance is the method of business organization, but since it is less important it may be discussed first.

The corporate form of business organization. — As the large scale movement progressed, and before it had got very far, the size of the most efficient plant that the market would allow surpassed the amount of capital at the command of one or even several individuals within a given locality. This need for greater amounts of capital was met by the introduction of the corporate form of business organization whereby shares of stock may be sold to any one who has a sum of money that he wishes to invest. This permitted the obtaining of funds from many classes of people and in some instances from distant countries. Under this form of organization there is no limit to the amount of capital that can be commanded so long as the affairs of the corporation are kept in a condition that will attract new capital.

There is also less risk to the individual investor under the corporate form of organization than under the others. An individual who enters business for himself incurs the possibility of losing not only what he has put into the business, but the rest of his property also. Under the partnership form of organization, one individual can be held responsible for the debts of the firm to the full amount of his property, even though not invested in the business. But under the corporate form, a single investor loses only the amount of his investment in case the business fails. The reason is that the stockholders in a corporation are granted the privilege of limited liability; that is, the liability of the stockholder is limited to the amount of capital actually invested in the business. If the business fails he loses this, but the rest of his private fortune cannot be seized to pay the debts of the bankrupt business, as could be done in the case of a partnership or firm. This immunity makes people willing to invest capital in industries which are organized under the corporate form with limited liability.

Two types of large scale industry.[1] — There are two types of industry in which the advantages of large scale production are so great that in these fields the small establishment has almost ceased to exist. The first type comprises those industries which handle very large single *masses* of material; the iron and steel industry is the best example of this. The other type comprises those industries which handle the raw material in a continuous *stream*, like a paper mill or a flour mill, or in a continuous *series* of operations, like a meat packing establishment or an automobile assembling plant. In both types the economies of operation are altogether on the side of the large scale enterprise. The actual technique of production for all of these industries is described in subsequent chapters. Here only those conditions which favor operation on a large scale will be discussed.

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[1] The distinction between these two types is made by Professor Alfred Marshall in his *Trade and Industry* (London, 3rd ed., 1920), pp. 218, 235.

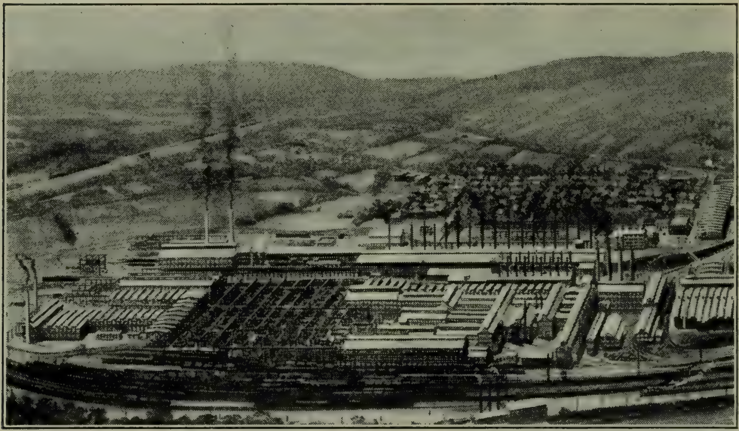
The iron and steel industry. — The facts as to the growth of the iron and steel industry since 1879 are presented in the following table:

Year	*Number of establishments*	*Average number of wage-earners per establishment*	*Average amount of capital per establishment*	*Average value of product per establishment*
1879	699	197	$ 295,000	$ 419,000
1889	699	250	591,000	683,000
1899	668	333	858,000	1,203,000
1909	654	426	2,265,000	2,119,000
1919	695	599	4,982,000	5,642,000

This table shows very strikingly the tendency toward large scale production. During this forty-year period the number of establishments has actually declined, but the size of each has grown enormously. The average number of wage-earners per establishment has trebled, but the capital employed has increased seventeenfold, showing that the use of machinery has grown much faster than of human labor. At the same time the output has expanded in similar fashion.

Impressive as are the figures of expansion of the average establishment in the iron and steel industry just given, they do not give an adequate picture of the enormous growth in size of the individual producing units. Thus the average capacity of the blast furnaces increased during this period from 25 tons per day in 1879 to 148 tons twenty years later, and to 1500 in 1919. The average daily capacity of a Bessemer converter grew at the same three dates from 5 to 15 to 25 tons, and that of the open hearth furnace from 10 to 50 to 125 tons, although the average is from 60 to 75 tons.

Economies of the large iron and steel establishment. — The central task in the manufacture of steel is the handling of masses of molten iron, ready to be made into steel, this later to be subjected to further processes for converting it into finished products of the desired quality, size, and shape. The most economical size of a business unit in the steel industry, whether a blast furnace, a Bessemer converter, or a rolling mill is one that can handle these huge masses easily and quickly. This can be done only by mechanical appliances, such as great ladles each holding several tons of liquid iron or steel, traveling cranes which pick up massive pieces of metal and carry them safely from one part of the plant to another, and great trip hammers and rolling tables which crush into shape ingots weighing thousands of pounds. Man's part in this work is confined pretty much to pulling levers and turning handles. In an industry of this character, the advantage is all with the large scale plant, for the cost of constructing larger machines does not increase proportionally with their size, and it requires no more effort on the part of a worker to pull a lever which sets in motion a large crane than a small one. The industry tends, therefore, to be concentrated in a few very large establishments, which have expanded horizontally until they have become of mammoth size.



A PART OF THE BETHLEHEM STEEL PLANT

The steel works of the Bethlehem Steel Company extend for a distance of 3¼ miles along the south bank of the Lehigh River, and comprise the Lehigh Plant, the Saucon Plant, and the Northampton Plant. These plants occupy an area of 820 acres in Bethlehem, Pennsylvania.

Vertical expansion of the iron and steel industry. — The technique of the industry also favors vertical expansion, that is bringing under unified control the various stages of the industry from the extraction of the raw materials to the delivery of the finished goods. There is a great economy if the molten iron from the blast furnace can be delivered, while still hot and liquid, to the Bessemer converter or open hearth furnace to be converted into steel, instead of being made into pig iron which will have to be transported to some other plant and there melted again. There is a similar economy if the white hot ingots can be carried direct from the ingot mold to the rolling mills without loss of heat. The waste gases from the blast furnaces can also be used to furnish the hot air blast in the open hearth furnaces or to provide electricity for other branches. The different branches of such a great vertically expanded organization as the United States Steel Corporation play directly into each other's hands, and their intelligently directed coöperation permits great internal economies.

Industries which handle continuous streams of materials. — The second type of industries in which the large scale establishment has great advantages over the one of small or even moderate size is that which handles materials in a continuous stream or in a series of operations. Under this type there are thus really two species.

The first of these may be illustrated by a paper mill or flour mill. In each case the material is reduced to a perfectly homogeneous form — a liquid mass of paper stock in the one case or a powder in the other — which passes in a continuous stream from one operation to another. It is clear that if such a process is to be used there must be a steady supply of raw materials and a market which will absorb the output. The old-fashioned local flour mill, run by water power generally, which is still found in many places in the wheat belt in the United States, lacks both these conditions, and is consequently an expensive establishment to operate compared with the great mills at Minneapolis. In this type of industry, also, automatic machinery can be and is largely used, so that the work is carried on from beginning to end with scarcely the touch of human hands. The economies of operation in these and similar industries lie entirely on the side of the large scale establishment.

The other species comprises industries which handle material which is not homogeneous, but which is passed through a continuous series of operations in the process of manufacturing. Illustrations are the meat packing and automobile assembling industries. In the former a hog or steer is suspended from a rail and passed with the utmost rapidity from one operation to another; an endless flow of animals passes without ceasing through the same series hour after hour. In the assembling plant of an automobile factory the component parts of, say, the chassis are placed upon an endless conveyor; as it passes each workman he picks up a particular part and attaches it. By the time it has reached the end of the line the chassis is complete. In both these industries automatic machinery is largely used, but even more characteristic is the breaking up of the processes into simple routine operations which the same worker repeats over and over again. His actions thus become nearly as accurate and as automatic as those of a machine itself. This high degree of specialization and skill can be achieved only in a large scale establishment. Here again the advantages are with the large producing unit.

Statistics of these industries. — Statistical evidence to substantiate these statements is furnished in the following tables:

PAPER AND WOOD PULP

Year	*Number of establishments*	*Average number of wage-earners per establishment*	*Average amount of capital per establishment*	*Average value added to product by manufacturing per establishment*
1879	742	34	$ 65,000	$ 30,000
1889	649	48	138,000	53,000
1899	763	65	219,000	74,000
1909	777	98	527,000	132,000
1919	729	156	1,242,000	439,000

FLOUR MILLING (merchant and custom mills)

Year	*Number of establishments*	*Average number of wage-earners per establishment*	*Average amount of capital per establishment*	*Average value added to product by manufacturing per establishment*
1879	24,338	2.4	$ 7,000	$ 2,600
1889	18,470	2.6	11,000	4,300
1899	25,258	1.5	8,700	3,400
1909	23,652	2.0	10,600	5,300
1919	21,135	2.2	39,000	13,000

SLAUGHTERING AND MEAT PACKING

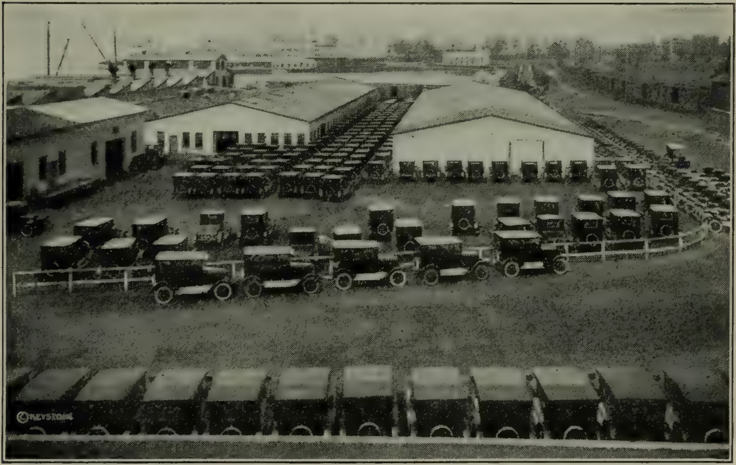
Year	*Number of establishments*	*Average number of wage-earners per establishment*	*Average amount of capital per establishment*	*Average value added to product by manufacturing per establishment*
1879	 872	31	$ 57,000	$ 41,000
1889	1,367	33	86,000	59,000
1899	 882	77	214,000	115,000
1909	1,221	72	309,000	134,000
1919	1,304	123	902,000	355,000

AUTOMOBILES [2]

(Does not include the manufacture of bodies and parts;
only the assembling operations)

Year	*Number of establishments*	*Average number of wage-earners per establishment*	*Average amount of capital per establishment*	*Average value added to product by manufacturing per establishment*
1909	265	194	$ 508,000	$ 325,000
1919	315	668	4,160,000	2,569,000

The advantages of large scale production. — Large scale production has developed because there existed in it certain economies which gave to the establishments which adopted it distinct advantages over their competitors who operated on a small scale. The economies do not exist in all lines of industry, and where they do not, the small scale industry persists. Illustrations of such small scale industries are fruit and vegetable canning, millinery, picture framing, laundry work. Among the large establishments there also goes on a competitive struggle, which results in the more efficient



LARGE SCALE PRODUCTION

This is a view of the exterior of the Chevrolet factory at Tarrytown, New York.

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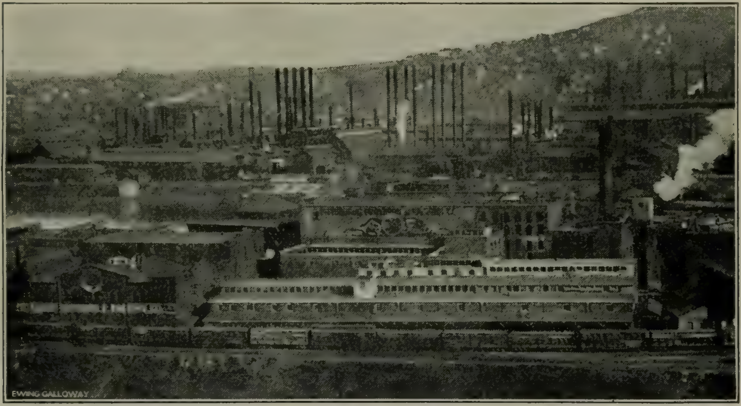
[2] Not given separately until 1909. Included with carriages and wagons previous to that time.

one crowding out the less capable or bringing about combinations with them, until the advantages of expansion have been exhausted. At this point of most efficient size the industry will become stabilized. This point will moreover vary with the particular industry; for an iron and steel establishment it will be much greater than for a cotton mill, and larger for a meat packing plant than for a cheese factory.

Enterprisers or managers of industry are striving for factories of a size that will give the maximum of efficiency for the expense incurred, or for the most perfect combination of the factors of production — land, labor, capital, and management. With a given condition of demand, there is a certain combination of these factors which results in the lowest cost of production per unit of product. This is what manufacturers are always striving to attain. Some of the more general considerations, which are common to various types of industry and which favor large scale establishments, may now be discussed.

Economy in management. — The success of an enterprise is due in large part to the manager — to his ability to employ in the proper amounts and proportions and to arrange in the best possible series the other factors of production, the land, labor, and capital. In the large establishment it is possible to extend the principle of the division of labor into the managerial and minor executive positions. Specialists are put in charge of particular departments, in the management of which they become very skilled. Moreover, the costs of administration and supervision do not increase proportionately with the size of the establishment, for a capable man can administer a large department about as effectively as a small one. The additional force needed in the large establishment will consist of clerical workers or routine workmen, whose wages do not add proportionately to the expenses of production. These highly specialized and skilled managers are paid high salaries, which the small concerns are unwilling or unable to pay; and here again an advantage accrues to the large scale enterprise. The presence of these able managers adds to the efficiency of the larger concerns and makes them still more able to compete with and undersell the smaller, less efficient ones.

A limiting factor in the rapidity and extent of the development of large scale industry is the scarcity of outstanding managerial ability. Enterprisers possess varying capacities and there are only a very few at any one time of exceptional ability, such as Andrew Carnegie, or Henry Ford. Graded down from these industrial leaders are others of less insight and imagination, whose capacities limit the scope of the enterprises which they administer. As the science of management itself becomes reduced to general principles this limitation tends to become less restrictive, and the establishment or concern expands to its technical limits.



Pittsburgh's Steel District as Seen from Troy Hill

Just behind the packing houses in the foreground, are the buildings of the Carnegie Steel Works.

The use of machinery. — The description of the technical conditions of production in the preceding paragraphs showed that those industries in which the advantages of large scale production were greatest, made extensive use of machinery. But highly specialized automatic or semi-automatic machines are very expensive, and cannot be profitably installed unless the scope of the business is such as to ensure their continuous use at full capacity. When a factory is small, an expensive machine cannot ordinarily be afforded, and even if it is purchased, it often has to remain idle while some of the other processes are being performed, because of the small number of workers and the impracticability of a perfect division of labor.

The use of machinery is one aspect of the division of labor. In a large establishment a more minute division of labor and a higher degree of specialization is possible than in a small one. Complicated processes are broken up into a number of simple routine operations, which are performed over and over again by the same person. If labor is expensive this repetitive operation will be handed over to an automatic machine; if labor is relatively cheap, it may still be performed by hand. But in either case the advantage lies with the concern which can carry the division of processes to the point of maximum efficiency; generally this will be the large scale establishment.

Cheap power. — To drive the machinery used in modern industry requires power. In the production of this the advantage rests with large concerns, since power can be produced more cheaply per unit when it is produced in large quantities. From the standpoint of cost it is well known that the method of heating private residences with separate furnaces is relatively uneconomical. A central heating plant for a group of buildings or for a number of apartments in the same building is cheaper than the combined costs of separate heaters for each one. The same thing is true of electric lighting; small electric light plants operated by gasoline motors, which produce electricity for local use, do so at greater cost per unit than the same amount of current furnished by a central power station. So also in a large factory the cost of installing a steam power plant is relatively less than in a small one, and the costs of operation are considerably less per unit of power. The large scale steam raising machinery is also much more efficient than the small steam engines which are still found in many places.

This particular advantage tends to become less important with the growing use of electric power. This can be produced more economically in great central plants, from which it is transmitted at high voltages and over long distances to the points of consumption. Such power can be furnished almost as cheaply to the small user as to the large concern. The importance of this movement is shown by the figures showing the kind of power used in factories in the United States. In 1923 over 16,000,000 h.p. or about fifty per cent was derived from steam engines and over 13,000,000 h.p., or about forty per cent was rented electric power. Some writers see in this movement a force which may eventually decentralize our industries and split them up into smaller producing units.

Less waste of material. — Large establishments waste less material than small ones. This is because of a better specialization of labor and machinery and the possibility of utilizing materials of a poorer grade, as the extraction of the minerals from low grade ores.

Specialized labor and machines waste less raw material in scraps and odds and ends. This is evident in the manufacture of shoes and garments. In cutting the parts of a shoe or a garment from the raw material, a skilled worker who puts in all of his time at such operations will waste less than a worker who does several things, as is necessary in a small plant. Continuous practice makes him very adept at such operations. A specialized machine in which the raw material is placed in a fixed position wastes still less. But a small factory cannot afford the machinery or the services of highly specialized labor.

Use of by-products. — Small factories can seldom save by-products because of the added cost involved in providing the equipment and labor necessary to utilize them. The volume of by-products in a small plant is not large, and they must usually be disposed of as waste or sold to another company for what they will bring. Ordinarily, only a very large establishment can afford to utilize its waste products. To the country butcher about one-half of an animal consists of waste which he cannot utilize, but the large packing plant converts this waste into a hundred or more by-products. According to Swift and Company, the following products are derived from a steer:

Percentage of Weight of Finished Products to Weight of Live Steer

Beef		54.3%
By-products		
Hide	5.9	
Fats	2.2	
Head	2.2	
Feet	1.1	
Blood	.7	
Casings	.8	
Miscellaneous	3.2	
Total by-products		16.1
Valueless		10.1
Shrinkage		19.5
		100.00

Among the commodities manufactured from these by-products may be listed the following: glue, fertilizer, animal feed, leather dressing, oleomargarine, lard compounds, soap, glycerine, gelatine, buttons, combs, pharmaceutical and medical products, and sausage containers. These by-products are important factors in contributing to the profits of the industry, and allow consumers to obtain the main product at a lower price than if they were not saved. The saving of these materials, which would otherwise go to waste, may also be considered a social gain.

It is not an accident that the large scale industry, which handles great quantities of homogeneous products, should utilize the by-products. The standardization of the processes of manufacture tends to separate and throw out at each stage those elements which are not an integral part of the main product. Great quantities of special by-products accumulate at these stages, whose utilization calls for the development of new processes and the establishment of subsidiary industries.

Development of scientific research. — The determination of the value of these by-products, and the development of new processes by which they shall be utilized, calls for painstaking research and sometimes the expenditure of large sums of capital. Some of the by-products finally obtained are subtle and costly chemical compounds, as adrenalin and insulin and other pharmaceutical products. To discover these and to devise methods of producing them in commercial quantities at reasonable cost is the work of the research department. But only a large scale industry can afford the expense of maintaining laboratories and carrying on experiments which may not yield any results for years. They alone can afford to employ a large staff of trained experts for the purpose of devising methods of utilizing by-products or what has hitherto been regarded as waste. If they are successful their profits will be very large. The small companies have neither the capital nor the incentive to carry on such work. It has been estimated by the United States Chamber of Commerce that American manufacturers spend about $35,000,000 each year on scientific and research work, and that the annual savings effected are about $500,000,000. The large industry, then, is working for the advancement of science as well as for the production of cheaper and better commodities.

Large scale production a social gain. — The great advantage of large scale production from a social point of view is that it effects great economies of production. As a result of the utilization of mechanical devices and of machinery, there is a great saving of human labor, which must always be counted a gain. A smaller number of workers can produce as much as a larger number under a less efficient system. There is also an economy of capital, for machines and other equipment can be used continuously without any waste from standing idle. More specialized and efficient machinery can moreover be devised and used when large quantities of uniform materials are being handled. And finally there is a great economy in raw material; not only is there less waste in the utilization of the main product, but the by-products can frequently be saved and made the bases of subsidiary industries. In all these ways a larger return can be obtained, and the costs of production can be lowered.

The large scale concern tends also to stabilize industry in its field. Having a great command over supplies of raw material and of the finished goods, it is able to coördinate these somewhat more effectively than a number of scattered small scale producers. It may draw its raw material from many different sources, scattered perhaps over the whole world, so that the failure of one will be offset by the success of other producers. Similarly, the wider markets permit a steadier and more uniform policy of manufacture. This result may also be obtained by the combination of small concerns.

It is evident from what has been said that there are limits to the spread of large scale production, and that these limits are imposed primarily by the technique of the industry. Those industries can best be conducted on a large scale which handle large masses of uniform materials or which carry the materials in a stream or in a series of repetitive processes through the different stages of manufacture. These conditions are best met in certain lines of manufacture; but even here there is an optimum or most efficient size, beyond which, in any particular industry, it is not wise to go. Thus, the optimum size for a cotton mill will be smaller than for a steel plant. Those industries which do not meet these conditions will continue to be carried on best as small scale industries; such are aquaculture, agriculture, personal and professional services, and some lines of manufactures in which the non-uniformity of the material or the need of artistic workmanship necessitates a great deal of hand labor.

SUGGESTIVE QUESTIONS

1. Distinguish carefully between vertical and horizontal expansion of industry. To which class does the Ford Motor Company belong? the United States Rubber Company? the American Sugar Refining Company? the Royal-Dutch-Shell Oil Company?
2. Which is more desirable or undesirable, economically and socially: vertical or horizontal expansion? Explain.
3. Has the growth of large scale production tended to destroy initiative and make nearly impossible the rise of a young man to the position reached by many of the older captains of industry?
4. Name a product which has an international market, one with a national market, one with only a local market. What are the limiting factors in the latter cases?
5. What factors determine the volume of a market?
6. Distinguish between the localization of industry and the concentration of industry.
7. Is there any relationship, necessarily, between the corporate form of business organization and large scale production?
8. Analyze the figures in the tables of this chapter and see if you can account for the changes from one decade to the next. Is the increase in the size of the scale of operations responsible for all changes?
9. What, in your mind, are the most important advantages of large scale production?
10. Can you give an instance of a large concern crowding out a small one?
11. Do you know of any cases where a large concern failed in its competition with small ones? What was the basic cause of its failure?
12. Why are the by-products of the lumber industry not saved to any extent in the United States?
13. Is the existence of many small industries or businesses more or less desirable than of a few large ones? Why?
14. Can you give an illustration of a case where improvements in transportation have contributed to large scale production?
15. Make a list of all the advantages which you can think of for a small scale industry. How do they compare with the advantages claimed for large scale production?

BIBLIOGRAPHICAL NOTE

The best material on large scale production is found in chapters in the general books on economics and business organization.

One of the clearest discussions of the economics of large scale production is in F. W. Taussig, *Principles of Economics*, vol. I (New York, revised 3rd ed., 1923). Also good are E. R. A. Seligman, *Principles of Economics* (New York, 11th ed., 1926) and A. S. Johnson, *Introduction to Economics* (New York, revised ed., 1922). C. Gide, *Principles of Political Economy* (New York, rev. ed., 1921) is good but not so well organized as the above books. Excellent illustrative material may be obtained from the *Reports of the Federal Trade Commission* (Washington) on various industries, and from the *Report of the Industrial Commission of 1900* (Washington). Good illustrative material is found in E. Jones, *The Trust Problem in the United States* (New York, 1922). Interesting historical material is found in Ida Tarbell, *History of the Standard Oil Company* (New York, 1904, 2 vols.); *The Life of Elbert H. Gary* (New York, 1925), by the same author; M. Jacobstein, *The Tobacco Industry in the United States* (New York, 1907); and A. Berglund, *The United States Steel Corporation* (New York, 1907). These books are old but they trace the development of the particular industry through its period of growth from a small scale to a large scale enterprise. The best statistical material available on the growth of industries is in the volumes of the *United States Census Reports* (Washington, Decennial). These reports also contain valuable descriptive and historical material.

CHAPTER XXIX

CHEMISTRY AND MODERN INDUSTRY

Importance of chemistry. — Modern industry is dependent upon the science and art of chemistry at almost every turn. The publisher depends upon them for his paper, the printer for his ink, the automobilist for his tires and tubes, his gasoline and oil, the shoemaker for his leather and the blacking with which the shoes are polished. The chemist produces the dynamite with which a mine is opened, the processes for converting iron into steel, and the materials for welding it; the artificial silk of which a pair of stockings is made and the dye with which they are colored; perfumes and fertilizers; glass and iron; and innumerable other materials. The all-pervasiveness of chemistry is well illustrated in the following story: [1]

" ' What does chemistry mean to me? ' said Mr. Narrowhead as he looked at this page, printed with ink made by a chemical process, on paper made by a chemical process.

" As he pushed back his cuff, bleached by a chemical process, and laced his shoes made of leather, tanned by a chemical process, he glanced through a pane of glass, made by a chemical process, and saw a baker's cart full of bread, leavened by a chemical process, and a wagon delivering a parcel of silk, made by a chemical process.

" He pulled out his pencil, made by a chemical process, and wrote a reminder in his notebook bound by imitation morocco, made by a chemical process.

" Then he put on his hat, dyed by a chemical process, and stepped out upon the pavement of asphalt, compounded by a chemical process, bought a daily paper with a penny refined by a chemical process, and proceeded to the office where he dealt in a certain chemical compound called coal.

" ' No,' he added, ' of course not, chemistry has nothing to do with me.' "

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[1] H. N. Casson, in *Efficiency Magazine,* quoted by H. E. Howe, *Chemistry in Industry,* p. vi.

Purpose of chemistry. — Chemistry has been defined as the science which investigates the composition of material substances, and the permanent changes of constitution which their mutual actions produce. Having in view the practical results of the chemical industries one writer has described chemistry as " the science which fashions from the materials found in nature other substances which are better suited to the present needs of men." And another writer, impressed by the saving of time in chemical processes, has emphasized " that work of the chemist which, aided by the electric current, enables him to do in a few moments many of the things which, to the best of our belief, nature has required long ages to perform." [2]

The material substances which make up the earth's crust, the air, and the water, are composed of minute units known as atoms, molecules, and electrons. These have certain relations to each other, and certain groupings give rise to great changes in their composition or lead to the formation of new products, quite different from any of the component parts. The chemist, as a result of long and patient effort, has found out which arrangements of molecules are useful to man and which are harmful or useless. Upon this knowledge has been built up a vast number of industries which simply rearrange the atoms or molecules in such a way that they serve better the wants of man. Sometimes the chemist produces a new product, which the alchemy of nature has never brought forth, such as coal tar dyes; sometimes he merely shortens the time for the accomplishment of a given purpose, such as bleaching cotton cloth by the use of chlorine instead of sunlight. The mediæval alchemists sought for the philosopher's stone, which would transmute the baser metals into gold. The modern chemist has done something more wonderful and infinitely more useful, for he has transmuted the common materials all about us into products which serve our needs in a thousand ways.

Improving on nature. — Dr. E. E. Slosson has stated [3] that there are three stages in industrial progress: (1) the utilization of natural products, (2) the cultivation of natural products, and (3) the manufacture of artificial products. The first stage was that of savagery; the second began with the domestication of animals and the cultivation of plants and has lasted until the present time;

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[2] H. E. Howe, *Chemistry in Industry*, p. v.

[3] *Creative Chemistry*, p. 112.

the third stage was not possible until the physical sciences taught man the character and actions of the natural products and the forces of nature. The nineteenth century has been marked by an effort, ever more successful, to imitate the products of nature and where possible to improve upon them. In no sphere of industry have more artificial products been made than in that of chemistry.

There are other less spectacular but useful services which chemistry renders to industry. One of these is the control of the quality of raw materials, such as steel, alloys, lubricants, coal, paints, paper, cement, and many other objects. It is most essential for the manufacturer that he obtain goods of exactly the same quality and standard, and this he is able to insure with the aid of the chemist. Another service is that of finding suitable substitutes for materials which are difficult to obtain or unduly high in price. Still another is that of devising a method of utilizing by-products or waste products so as to make them a source of profit instead of cost. It is said that the utilization of the former waste products of the slaughtering and meat packing industries furnishes the profits paid by the large companies. Most of the large industrial corporations in the United States to-day employ their own chemists and sometimes maintain expensive research laboratories where work is done upon these and other problems in industrial chemistry.

Some materials of chemistry. — If chemicals are to be used largely in industry they must be both plentiful and cheap. It is therefore essential that the most used acids, alkalis, and salts should be made so far as possible from readily available common materials. Those most readily available are air, water, and some abundant minerals like sand, salt, and limestone. These form the bases for the production of the most useful heavy or industrial chemicals. A few illustrations will make this point clear.

One of the most basic chemicals for industry is sulphuric acid, which is composed of sulphur, oxygen, and hydrogen. Oxygen is found uncombined in the air, of which it forms one-fifth by volume; it is also found, combined with other elements, in water and in many other materials. Hydrogen is best obtained from water, of which it forms one-ninth by weight. Sulphur is found in a free condition in volcanic regions; it is also present in certain sulphide ores and in other combinations. The problem presented to the chemist was, how to extract and combine these elements so as to produce sulphuric acid. The methods may be ascertained from any text-book of chemistry and need not be detailed here; it is sufficient to note that the problem has been satisfactorily solved, and sulphuric acid to-day is produced in large quantities and enters vitally into many industries.

Its production has at the same time been so cheapened that it now costs less than a cent a pound, whereas it originally cost about $1.25 an ounce or $20.00 a pound. With it dynamite is made, gasoline and lubricating oil are purified, and it is used in the production of textiles, tin cans, radio outfits, white paper, fertilizers, celluloid, artificial leather, dyestuffs, many medicines, and numerous other equally useful things.

CHEMICAL RESEARCH LABORATORY

This is a view of the laboratory in one of the large Chicago packing plants, and illustrates the extent to which industry makes use of modern science.

A very common mineral is salt, which is found in salt beds and mines. Salt is useful in itself, both as a condiment, to make food more savory, and as a preservative, to keep meat and fish from decay through the winter when food is scarcer. But even more useful are the elements of which salt is composed, namely sodium and chlorine. It has been found possible, by the use of an electric current, to separate these atoms and to obtain from them caustic soda and chlorine, both of which are largely used in industry to-day. Caustic soda is used for making soap, mercerizing cotton, manufacturing artificial silk, and for other purposes. Soda is as important among alkalis as sulphuric acid is among acids.

Chlorine, the partner of sodium in salt, is a dangerous and destructive gas if allowed to run wild. This was the first poison gas used in the World War by the Germans, in April, 1915; and entered into other gases, like mustard gas, which came to be used more generally later in the War. Its most important industrial uses are in the manufacture of bleaching power, in the purification of drinking water, and in the making of dyestuffs and medicines.

As further illustrations the fertilizer, cellulose, and glass industries will be described in more detail.

Agricultural chemistry. — In 1840 Justus von Liebig for the first time made a scientific study of the chemical composition of soils, ascertained the constituent elements, and suggested the possibility of maintaining soil fertility by the introduction of the chemical elements which were lacking in any particular case. This marks the beginning of agricultural chemistry and of the modern fertilizer business. While this was the beginning of the application of chemical science to agriculture, it was by no means the first use of fertilizers. Almost from the beginning of agriculture we have records of the use of manure, bones, and refuse of various kinds to fertilize the soil. When the Pilgrims planted their first crop of maize in the colonies they were instructed by the Indians to drop a fish into each hill which they planted. Two thousand years ago the Roman poet Virgil, who was very fond of farming, wrote in his Georgics:

> "But sweet vicissitudes of rest and toil
> Make labor easy and renew the soil;
> Yet sprinkle sordid ashes all around,
> And load with fatt'ning dung the fallow ground."

But all these early practices rested simply upon experience and rule-of-thumb methods; it is certain that the principles underlying their beneficial results were not yet understood.

It is now well known that plants require food, just as human beings do. Some of these plant foods are mineral substances which are supplied by the soil, and if they are lacking the plant will not thrive. Just as human beings must have a balanced ration, comprising proteins, carbohydrates, vitamins, etc., so plants must have certain elements if they are to flourish. If these are lacking in the soil, or if they have been exhausted by injudicious cropping, they must be supplied in order to make the soil productive. This is done by the use of fertilizers.

The principal plant foods. — In his stimulating book, *Creative Chemistry,*[4] Dr. E. E. Slosson describes the principal plant foods as follows:

" Out of the eighty elements only thirteen are necessary for crops. Four of these are gases: hydrogen, oxygen, nitrogen and chlorine. Five are metals: potassium, magnesium, calcium, iron, and sodium. Four are non-metallic solids: carbon, sulphur, phosphorus, and silicon. Three of these, hydrogen, oxygen and carbon, making up the bulk of the plant, are obtainable *ad libitum* from the air and water. The other ten in the form of salts are dissolved in the water that is sucked up from the soil. The quantity needed is so small and the quantity contained in the soil is so great that ordinarily we need not bother about the supply except in the case of three of them. They are nitrogen, potassium and phosphorus. These would be useless or fatal to plant life in the elemental form, but fixed in neutral salt they are essential plant food. A ton of wheat takes away from the soil about 47 pounds of nitrogen, 18 pounds of phosphoric acid and 12 pounds of potash. If then the farmer does not restore this much to his field every year he is drawing upon his capital and this must lead to bankruptcy in the long run."

In order to illustrate the service which chemistry renders to industry it will be sufficient to follow the fortunes of these three important elements and ascertain how they are made available for agriculture. Phosphorus is usually supplied as a commercial fertilizer in the form of acid phosphate and is known to the trade as phosphoric acid. Potassium — always called potash by the manufacturer — appears in the form of mineral salts not unlike table salt, and like salt is easily soluble in water. Nitrogen, the third of this important trio of plant foods, is obtained from two different sources: the animal or plant kingdom and the mineral kingdom. If derived from the first two it is called organic nitrogen, and if from the latter inorganic. These will now be described in more detail.

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[4] P. 37.

Phosphates. — The ancients were in the habit of burying old bones as fertilizers. Later it was found that better results were obtained if the bones were ground up into bone-meal. In this country the buffalo bones from the prairies and bone-meal from the packing houses were first used, but these supplies soon ran short as the country expanded. Fortunately, in 1862 there were discovered in South Carolina large deposits of so-called rock or natural phosphates, which are simply the bones of prehistoric animals. Similar deposits were found in Florida in 1888, and later pebble beds were found in the same state, which are the chief source of the present supply. Phosphate beds also exist in Tennessee and Kentucky, Idaho, Wyoming, and some other western states, so the United States is well supplied with this particular plant food.

Before these natural phosphates can be made available for plant food, however, the chemist must give his aid, for they are not very soluble as they come from the ground, and the plant can appropriate only what it can get in the water which it sucks up from the soil. The chemist discovered that if the phosphate is treated with sulphuric acid it becomes more soluble. The sulphuric acid is itself a chemical product, as has already been pointed out. But there are other difficulties to be solved before the natural phosphate can be made available as plant food. Iron and aluminum occur in these in such large amounts as to be harmful, and it therefore becomes necessary to get rid of them. Although this can be done successfully, the present method is very wasteful, for it involves the throwing away of two tons of rock phosphate for each ton of acid phosphate brought to market. Further work evidently remains for the chemist to do in eliminating this waste.

Potash. — Germany has had practically a monopoly of potash, now shared with France. In prehistoric times northwestern Prussia was scarcely above sea level and each year it was flooded by sea-water which left a deposit of ocean salts from three to five inches thick. In the course of some ten thousand years immense beds of potash-bearing salts, often 5000 feet in depth, accumulated. These were first worked for their salt, but about 1859 it was discovered that they contained potash and after that date they began to be used as fertilizer. Before the World War American farmers imported annually from Germany about $17,000,000 worth of potash.

The United States has an inexhaustible source of potash in potassium-bearing rocks, but the chemists have not devised a cheap and practicable method of making these available for plant use. It must not be forgotten that potassium, like phosphorus, in the form in which it occurs in these rocks, is insoluble in water, and that the plant can utilize only those elements which it sucks up in the soil water. Until potash is produced elsewhere in a form which will fit it for plant use, we shall have to depend largely upon the natural deposits in Germany and France.

Other sources in the United States from which limited supplies of potash have been obtained are wood ashes, the gases from cement plants and blast furnaces, beet molasses and waste liquors, alunite, deposits in alkali lakes in Nebraska, Utah, and California, kelp or giant seaweed in the Pacific Ocean, and a few other industrial wastes. During the World War, when we were cut off from German supplies, the government of the United States spent over $50,000,000 on chemical research in the effort to discover an economical method of utilizing these sources, but without much immediate success, although the total domestic production of potash was raised to 52,135 tons in 1918, or about one-sixth of what we needed. As a result of the lack of potash for fertilizer there was a marked decrease in the yield of certain crops, rust appeared in cotton, and other evils showed themselves. Since then, however, practicable methods of utilizing the deposits in the alkali lakes have been worked out, and large amounts of potash are now obtained from California. Here is another industrial and agricultural problem which waited for the chemist.

Nitrogen. — As already stated, nitrogen is obtained from organic sources such as sewage water, tankage from packing plants, cottonseed meal, and similar materials; or from inorganic sources or mineral salts, such as Chile saltpeter. Since about five-sixths of the nitrogen in commercial fertilizers comes from inorganic sources this paragraph will be confined to these.

Probably the richest beds of nitrates which ever existed in the world were the guano deposits on the islands off the coast of Peru, where for centuries penguins and pelicans had piled up their excrement with the remains of dead fishes and their own bones to a depth of 120 feet. From these islands a billion dollars worth of guano was taken before the deposit was exhausted. Similar deposits were next discovered on the mainland of Peru and Chile in the form of sodium nitrate or " Chile saltpeter." These now constitute the chief source of supply, but at the present rate of exportation will last probably not more than a few years longer. There is here presented to chemistry a vital and imperative problem, for it is clear that we cannot long depend upon Chile for our supplies of nitrogen.

Nitrogen exists all about us in exhaustless supplies in the air, of which it forms a high proportion. But in this form it is not available as plant food except for a few legumes (clovers, peas, beans, etc.), but must be separated from the other elements and absorbed from the soil. The fixation of nitrogen, as it is called, is the problem upon which the industrial chemists have been working. Thus far our chief reliance has been the gas which is given off in coke ovens when coal is coked; from this gas, nitrogen and a number of other valuable by-products such as ammonia and coal tar are being recovered in larger quantity with each succeeding year. Since this is only a by-product of another industry, however, the supply cannot expand in response to an increased demand from the farmer; the amount from this source is relatively a fixed quantity. There remains therefore but one method of increasing our supplies of nitrogen, and that is to obtain it from the atmosphere itself. New processes are being developed for tapping the air directly and fixing the atoms of free nitrogen so that they may be available for use as a fertilizer: the fixation of nitrogen from air has been satisfactorily accomplished and is now being practiced extensively by methods developed at the Fixed Nitrogen Laboratory in Washington. Plants are now in operation at Syracuse, New York, and elsewhere. In the United States the principal method used is the Haber process. In the solution of this problem the physicist and the chemist work together for the enrichment of agriculture and industry.

Cellulose. — Another illustration of the close relation between chemistry and industry may be found in the utilization of cellulose. If you will cut across any plant and examine the transverse section under a microscope, you will see that it is made up of innumerable cells. These cells contain protoplasmic materials which cause the growth of the plant, and the walls of the cells are cellulose. Cellulose is the skeleton of every plant, and makes up over one-third of all vegetable matter when dry. It is of enormous importance in modern industry, for upon it are based the paper making and textile industries, the manufacture of thread and twine and rope, high explosives, artificial silk or rayon, and celluloid products. Cotton is almost pure cellulose, as are also flax, hemp, and similar textile fibers; wood and cereal plants have a somewhat different composition.

The paper making industry is described in another chapter of this book. Here it is proposed to take up only some phases of the use of cellulose which depend in a very high degree upon chemical processes, and which illustrate again the contributions of chemistry to modern industry.

Mercerized cotton. — John Mercer, an English calico printer, in 1844 discovered that if cotton cloth or yarn be placed in a strong solution of caustic soda, the cotton would shrink, but would become fifty per cent stronger and would take dyes better. For nearly fifty years little practical use was made of this discovery, but it was then found out that, if the material was stretched so that it could not shrink during the caustic soda bath or before it dried, the twisted ribbons of the cotton fiber were changed into smooth-walled cylinders like silk. The resulting fabric has a silky sheen or luster, and is known as " mercerized " cotton. As it is much cheaper than silk, while sometimes almost indistinguishable from it, there has been built up upon these discoveries a large and profitable business in the mercerizing of both cotton yarn and cloth.

Artificial silk. — A still more spectacular step in connection with the textile industry was taken when artificial silk or rayon was produced. In spinning its cocoon the silkworm ejects through its minute spinneret a semiliquid substance which hardens into silk fiber upon being exposed to the air. Count Chardonnet was the first to conceive the idea of chemically reproducing this process by forcing collodion — with which we are all now familiar since we spread it on our cut fingers — through very fine capillary openings. This formed a very fine continuous thread with a luster even higher than that of silk. Other men began to experiment to produce artificial silk from other substances and by other processes until to-day there are four principal methods and as many varieties of artificial silk; but they all involve the same physical principle followed by the silkworm, of forcing a semiliquid substance through a very fine opening.

Almost any kind of cellulose can be used for this purpose — cotton, cottonwaste, rags, paper, and wood pulp. And the chemical raw matarials used in the processes of manufacture are equally cheap and plentiful, as they consist for the most part of salt, sulphur, carbon, air, and water, in addition to the cellulose. The artificial silk industry meets therefore the conditions necessary for the production of an article on a large scale at a price within reach of the mass of consumers. For this reason it may be regarded as a real triumph for chemistry, for a new material has been produced which has merits sufficient to make it an article of wide use. The added value which is given to the raw material may be illustrated from the following estimate by a popular writer: " a pine tree is worth $10 a ton; cut and stripped, it is worth $15; boiled into pulp, it is worth $40; bleached, it is worth $55; which, turned into viscose and spun into silk, is worth $5500."

Although these artificial silks are not so durable and have not the same tensile strength when wet as real silk they have the merits of beauty and cheapness. Artificial silk is usually combined with some other fiber, especially cotton; or it is used for braid and trimming, as in the clocks of a pair of socks, since it is more brilliant than natural silk. While flimsiness is a serious evil in modern methods of production, artificial silk seems well suited for the manufacture of articles in which changes of fashion are frequent and in which too great durability would constitute an economic waste.

Glass. — The manufacture of glass is both a mechanical and a chemical process. It was made long before the science of chemistry existed, but this science has done much to improve and expand it. The raw materials of glass are abundant and cheap; for common glass they are white sand, soda ash, and limestone. These are mixed and heated in a furnace until they melt, when the soft molten mass may be blown into bottles, tubes, etc., or pressed into various shapes such as bowls, lamp shades, and similar objects. Marvelous mechanical devices have been introduced into the industry such as the automatic bottle blower, machines to roll flat sheets of glass, and other appliances, but the most interesting recent developments are based upon chemical rather than mechanical processes.

Cut glass, with its beautiful play of colors due to reflection, is produced by the introduction of red lead instead of limestone and of pearl ash instead of soda ash. Optical glass is obtained by using substances which will eliminate all color from the finished product. Colored glass is obtained by the addition of certain ingredients; thus ruby glass results from using gold or copper or selenium, green glass from using iron, blue from using niter, and other colors from the introduction of yet other materials. Colored glass is of great importance in the making of semaphores, signal lights, and similar articles; it is also of great beauty in the manufacture of stained glass windows and of various glass ornaments. Window glass is strengthened by adding salt cake and alumina. Much as the chemist has done along the lines indicated much more remains to be done, and the future development of the glass industry seems to depend upon chemical research rather than upon further mechanical improvement. Pyrex is a new and industrially important kind of glass which resists sudden changes in temperature, and is being used where such a quality is desirable, as in baking dishes, oven doors, containers in the chemical industries, and allied purposes. Another glass which is extraordinarily resistant to temperature changes is quartz glass; this is made of pure sand. It is not merely heat resistant, but is transparent to rays of violet light, so that a room glassed with quartz glass will admit the sunshine as completely as though the glass were lacking. It is still very expensive, but the chemists are developing a process which should make it commercially successful; plenty of cheap raw material is available.

Conclusion. — Although many unsolved problems still confront the chemists in the application of chemical science to industry, it should be noted that actual chemical research has run ahead of industry. The laboratory work of investigation has been completed along many new lines and practicable methods of production and manufacture of many new articles have been worked out. The chemist has already done his part. The development of these new lines is not undertaken because it is uncertain whether sufficient demand exists to warrant the investment of capital in equipment. In some cases established industries might be disadvantageously affected, and there is therefore active opposition. Progress in the development of entirely new chemical products must rest primarily upon the education of the public as consumers, and of business men as enterprisers with sufficient imagination and scientific training, as well as capital, to follow the lead of the chemists into new fields.

SUGGESTIVE QUESTIONS

1. Can you state any ways in which chemistry has contributed to your well-being during the past twenty-four hours?

2. Write a definition or description of chemistry, based upon its purposes.

3. If a stadium were being built for your school or college, would the services of a chemist be required for testing the quality of the cement or the steel girders or any other of the building materials?

4. Describe some instance of the chemical utilization of by-products, which were formerly waste.

5. Ask some farmer within your acquaintance why he fertilizes his soil. Report the answer to the class.

6. Bring specimens to class, if possible, of phosphate rock and potash.

7. See if you can find the cellulose in some plant.

8. Are you wearing any articles which are made of mercerized cotton or rayon? To what other uses are these products put beside those mentioned in the text?

9. Name some other uses of glass in addition to those given.

10. Ask some chemist friend, who is employed in an industrial concern, to explain the nature of his work.

11. Even if you do not intend to be a chemist, do you think that a course in chemistry might possess for you (a) any practical value? (b) any cultural value?

12. Explain the Haber process of fixing free atmospheric nitrogen.

BIBLIOGRAPHICAL NOTE

No mention will be made here of text-books on chemistry, for the study of which there are numerous excellent standard manuals. The books which are described below may be read with profit by a layman who has had no training in chemistry.

The pioneer American books in the attempt to popularize chemistry and to insist upon its practical value to industry were R. K. Duncan, *The New Knowledge* (New York, 1906) and *The Chemistry of Commerce* (New York, 1907). The most widely read and stimulating non-technical book is undoubtedly E. E. Slosson, *Creative Chemistry* (New York, 1921). More careful and authoritative are two books edited by E. E. Howe, under the auspices of the Research Council of the Chemical Foundation and made up of articles by authorities on various subjects, *Chemistry in Industry* (New York, 1924) and *Chemistry in Agriculture*, (New York, 1926). Hugh Farrell, *What Price Progress?* (New York, 1925), is published under the same auspices.

An authoritative English work is A. Findlay, *Chemistry in the Service of Man* (London, 1924). Other semi-popular books are W. A. Tilden, *Chemical Discovery and Invention in the Twentieth Century,* (London, 1916); S. S. Stadtler, *Chemistry of Familiar Things* (New York, 1921); E. Cresey, *Discoveries and Inventions of the Twentieth Century* (New York, 1920); G. Martin, *Triumphs and Wonders of Modern Chemistry* (New York, 1921). A good manual on industrial chemistry is Allen Rogers, *Industrial Chemistry* (London, 3rd ed., 1920). On the fixation of atmospheric nitrogen, J. Knox, *Fixation of Atmospheric Nitrogen* (London, 1914), may be consulted.

PART VI

MANUFACTURING INDUSTRIES

CHAPTER XXX

MILLING

Classification of manufacturing industries. — It is possible to classify manufacturing industries in various ways, but in the following chapters they are divided into the three groups of (1) transforming, (2) chemical, and (3) assembling. Typical industries in each of these groups will be described.

(1) The characteristic feature of the transforming industries is that no chemical change is made in the raw material, but that it is subjected merely to processes which separate its parts and arrange them in different combinations, sometimes rejecting certain parts as waste. In most of these industries it is possible to use natural forces, such as gravity and the direct application of water power, to an extent that is not feasible in other kinds of manufacturing. Thus in milling flour or refining sugar large use is made of the principle of gravity, and careful attention must therefore be given to arrange the processes of manufacture in such a manner and order that advantage may be taken of this force and economical methods may be employed. Another characteristic of this group is the large use made of machinery. Since most of the processes are comparatively simple, or can be reduced to a simple routine, automatic machinery has to a large extent taken the place of human labor. Most large scale manufactures are of this type.

(2) The chemical manufacturing industries are those in which the raw material is subjected to processes which alter its character to such an extent that the finished good is different in kind as well as in appearance. Typical industries in this group are the manufacture of steel, cement, glass, soap, artificial silk, and coal tar dyes.

(3) The assembling type of manufacturing is well illustrated by the automobile, the steel ship, or the watchmaking industries,

which receive their raw material in the form of finished parts from other factories, and then put together these materials in such a way as to construct a new article. They themselves, however, do not manufacture the parts nor change them in any way.

If the same plant both manufactures and assembles the parts, there is really a combination in this case of a transforming manufacturing industry and an assembling industry under the same management. Indeed, it not infrequently happens in our great integrated industries that all three types of manufacture will be brought together under a single control. It will be found, however, that even in such cases the three types of manufacture will remain separate and distinct in different buildings and sometimes in different localities.

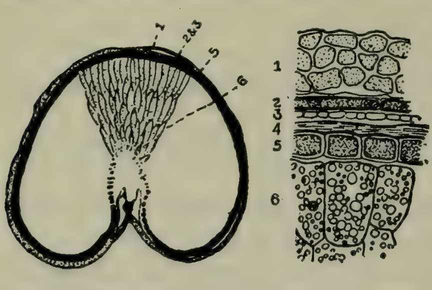
The milling industry will first be considered as a typical transforming manufacture.

Consumption of wheat flour. — The use of wheat as a human food is prehistoric, but its widespread use is comparatively recent. Not until the application of machinery to wheat harvesting and the development of new wheat areas permitted its cheap production on a large scale did it supplant the coarser grains in our dietary, such as barley, rye, maize, etc. But before it could be utilized as human food it had to be reduced to the form of flour by milling, and this process in its modern form dates back scarcely more than fifty years. It is evident therefore that we may regard modern milling as a comparatively recent industry, in spite of the antiquity of the art in its primitive form.

According to the census of 1920 the milling industry is the third largest manufacturing industry in the United States. There were in that year 11,000 merchant mills, engaged in buying cereals and selling flour and other products; in addition to these there were several thousand small neighborhood mills, grinding for a toll and milling not much more than a barrel per day for each mill. The description in the following paragraphs applies only to the largest merchant mills.

The consumption of wheat among European nations is greatest in France, amounting to about 7.8 bushels of wheat per capita annually. As it takes about 4.7 bushels of wheat to make one barrel of flour this is equivalent to 1.66 barrels of flour. Other important wheat consuming countries rank as follows: Belgium (7.2 bu.), Switzerland (5.7 bu.), United Kingdom (5.6 bu.), Canada (5.5

bu.), Australia (5.5 bu.), Spain (5.3 bu.), and the United States (4.9 bu.). Not only is the consumption of wheat less in the United States than in the other countries mentioned, but it has shown an appreciable decline since the beginning of the century. The average annual consumption for all purposes, however, still amounts to over one barrel per capita. Practically all of this is in the form of flour products.



Cross section of grain of wheat on the left. (From micro-photograph by Tolman.) Transverse section, on the right, of an unripe grain enlarged about 100 times from drawing by Bessey. 1, ovary wall or pericarp; 2, outer integument; 3, inner integument; 4, remains of nucellus; 5, aleurone cells; 6, starch cells.

What is a grain of wheat? — If you will examine a kernel of wheat you will note first of all that along one side there is an indentation, known as the crease, that at one end there is a beard or brush of tiny hairs, and that at the other end there is the germ or embryo. Each of these is of significance in the process of milling. Next, take a knife and cut various kernels, and you will find some harder than others; wheat may therefore be divided into hard and soft varieties, each of which produces a different kind of flour. A further classification may be made into spring and winter wheats, the former usually being of the hard variety and the latter soft.

The wheat kernel has three principal parts: the coatings, the starchy interior called the endosperm, and the germ.

The *coatings* of the kernel consist of an outer seed coat known as the pericarp and several inner coats; these are composed principally of cellulose and produce bran in flour making. They make up about five per cent of the weight of the entire kernel. Just inside the bran is a layer of large gluten cells known as *aleurone,* which make about three or four per cent of the weight. The gluten is important since upon it depend the baking qualities of the flour. The interior of the kernel, or the *endosperm,* is made up of cells filled principally with starch grains but containing also protein, some oils, and a little sugar; the cell walls are cellulose. This part of the kernel makes up eighty per cent or more. The *germ* or the embryo is the seed of the plant and is connected with the endosperm, from which it draws its food supplies during germination. The germ contains principally fats and oils.

All of these parts may enter into the flour, or some may be excluded. Graham flour is unbolted wheat meal containing all the parts. Whole wheat or entire wheat flour is wheat meal from which the coarsest of the bran has been removed, but it contains the embryo and some portions of the aleurone layer as well as the endosperm. White flour consists of the latter alone, the germ being excluded because it gives the flour a yellowish color and the other parts because of their coarseness. Usually from seventy to seventy-two per cent of the grain is made into flour.

Types of milling. — " The first miller," quotes Dondlinger, " plucked the berry from the stalk, and using his teeth for millstones, ground grist for a customer who would not be denied — his stomach." The method employed by this pioneer of grinding the kernel in order to separate the nutritious inside from the bran coating, is the one still employed; there have been changes only in the processes, designed to make the grinding easier and more effective.

Three types of mills may be distinguished, each of which uses a different process:

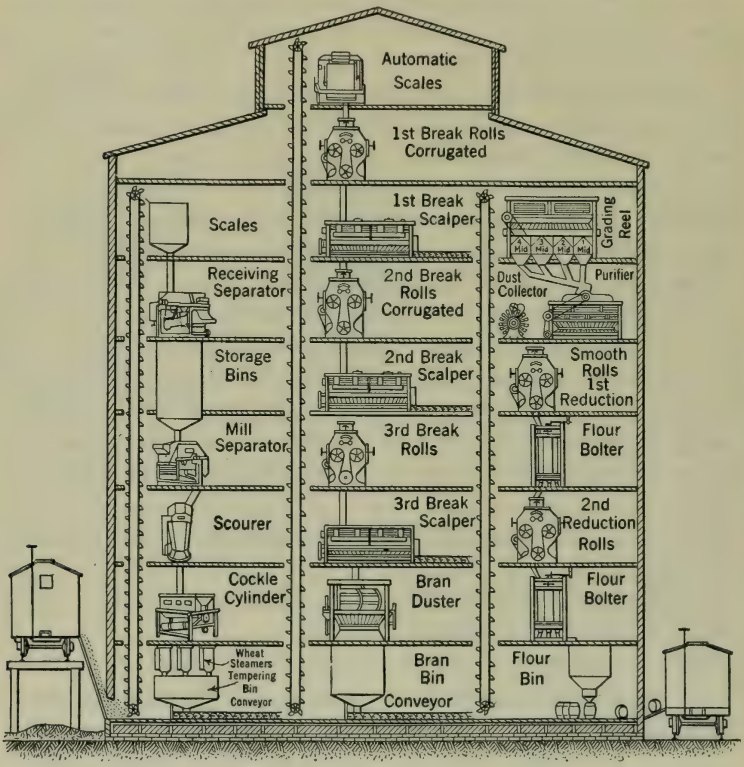
(1) The mortar and pestle type, in which the reduction of the grain is done by grinding and rubbing.

(2) The millstone type, in which the grain is crushed and ground between two roughened surfaces, of which one and sometimes both are kept in motion.

(3) The roller system, in which the grain is subjected to a gradual reduction or granulation by being passed through a number of sets of rollers, each set coming a little closer together and dividing the grain into smaller particles.

The first of these dates back to paleolithic times, and embraces several stages from the primitive hand stone to the more effective mortar and pestle. The latter is still used in compounding drugs and for similar purposes and need not be further described.

About 1870 several changes were introduced into milling methods in the United States, of which the most important was the substitution of rollers for the old millstones. These rollers were first made of porcelain and later of iron, and the principle was now followed of reducing the grain gradually by a succession of grindings, of which the last yielded a fine flour, instead of getting the flour from a single grinding as was done by the use of millstones. The roller system became known as the "new" process or "gradual reduction" process. Further improvements have made milling of wheat to-day a very scientific and exact process, especially in the largest mills.



SECTION OF A LARGE MODERN FLOUR MILL

This ideal cross-section of a mill shows clearly the sequence of the various processes through which the grain passes in the process of milling.

Preliminary operations. — Innumerable processes seem to be involved in the modern milling of wheat, but they can all be reduced to four fundamental operations: (1) cleaning, (2) tempering, (3) separation of the starchy interior or middlings from the other parts of the grain, and (4) the reduction of the middlings to flour.

After the grain is received it is carried at once by means of *elevators* to the top of the mill, where it is weighed. In a modern mill the processes are arranged in such an order that the grain, after being carried to the top, passes through several machines on its journey down to the ground, and is then carried up again by another elevator to descend through another series of operations. In this way the force of gravity is called to the miller's assistance.

Cleaning. — Wheat received at storage elevators, especially those at foreign ports, contains many foreign substances such as other grains and sand, dirt, sticks, etc., or damaged, smutty, and imperfect wheat grains. The receiving separators consist of several large sieves for separating out from the wheat some of the larger refuse, as corn, sticks, lint, and nails. The sieves are slightly inclined and have holes large enough to allow the grains of wheat to pass through; being kept constantly in motion the wheat falls through and the larger objects slide down the incline into receptacles.

From the receiving separators, wheat passes to the *storage bins* to be kept in reserve until needed. Only one bin is shown in the cut, but there is usually a series of them.

When required for milling, wheat is drawn from the bins to the *mill separators*. These are similar in principle to the receiving separators except that now the perforations in the sieve are too small to allow the wheat to pass through, so that all smaller foreign matter like sand, dirt, imperfect kernels, etc., are shaken down and the good wheat is retained.

While the wheat has now been separated from other articles which had become mixed with it, the wheat itself is not yet clean. The crease and the beard of each grain afford excellent repositories for dirt, and this must be dislodged before the wheat can be made into flour. For this purpose the *scourer* is employed. In this machine the wheat grains are thrown against perforated iron screens by revolving beaters. The impact loosens the dirt, which is drawn through the screens by a strong current of air. Some scourers have brushes attached for brushing and polishing the grain. This is known as the dry process of cleaning, but some mills wash the wheat, afterwards carrying it through a drying process. Better results seem to be obtained, however, by the dry process.

There is still one more process before the wheat is thoroughly cleaned, and this is the elimination of the cockle seed. The cockle is a common weed in the wheat fields, and the little black seed is of nearly the same size as wheat, so a special machine for removing them, known as the *cockle cylinder*, has been invented. If the cockle seeds were left in they would impair the quality of the flour.

Tempering. — It has long been the practice to temper or soften wheat by means of water or steam, or both, for the purpose of toughening the bran coat and keeping it from being too brittle. This is particularly necessary in the case of hard wheat. When the grains are sent through the rollers after being steamed, the pliable bran will remain in one large piece and not break into bits which will enter into the flour. Another purpose in tempering is to mellow the endosperm or starchy interior so that it will give the largest yield of flour possible. The grain comes through this process having a warm, moist feeling and ready for the grinding process.

The wheat has now reached the bottom of its first descent. At this point it is moved to another endless bucket elevator by a *conveyor*. Screw-conveyors or worms are shafts fitted with blades which fit snugly into a box or frame, so that any material introduced at one end is carried through to the other end. A familiar household example is a meat grinder or the action of an auger upon the particles of wood which it bores out. Many types are employed, but the purpose of all is the same, to convey the tempered wheat from the tempering bin to the elevator without the need of the intervention of human labor. The bucket elevator again lifts the wheat to the very top of the lofty building, where it is weighed again upon automatic scales, and is now ready for the third stage in milling, the separation of the middlings.

The break system. — The tempered wheat is next passed through several sets of rollers, known as *break rolls*, the object of which is to separate the endosperm from the bran covering and at the same time to make as little flour as possible. When the old method of grinding by millstones was used, it was difficult to separate the torn bran skins, the starch grains, and the germ, and the result was a poor quality of flour. Under the roller system the wheat berry is broken down very gradually, and at each step the freed particles of the endosperm or middlings are sifted out before subjecting the opened grain to the next break. The keynote of this process is gradual reduction, and it is accordingly broken up into several steps; grind and sift, grind and sift, is the order followed.

A set of iron break rolls is usually about forty to sixty inches long, the surface being corrugated or grooved and set so that the grooves come together like saw teeth. The first set has large and deep grooves, as the object here is to open the berry and remove some of the endosperm, but tearing and cutting the bran as little as possible. Gradually, as the wheat is broken down and smaller pieces have to be dealt with, smaller and shallower grooves are used, until those on the last break merely scrape or shear the last particles of the endosperm off the bran. The upper roll travels about two and one-half times as fast as the lower roll, and in the opposite direction. The superior speed of the fast roll tends to carry the grains through at its own velocity, but the sharp edges of the grooves of the slow roll resist this, so that a shearing action takes place, which detaches the flour particles from the bran.

Scalping. — The product which comes from the break rolls is composed of fine flour, flakes of endosperm (middlings or semolina), and the bran coats with pieces of endosperm still adhering to them. The next step is to separate or sift these, as each must be treated differently, and this is done by machines known as *scalpers*. There are various types of scalpers, some consisting of screens or sieves of silk or wire cloth through which the finer particles pass, others being operated by currents of air which separate the different particles on the centrifugal principle used in a cream separator. The fine flour is sent to the bolter, the middlings go to the reduction rolls to be ground into flour, but the bulk of the grain goes to the second set of break rolls.

The number of sets of rolls and scalpers varies in different mills from two to eight, but the usual number is four. At the end of the breaking process practically all of the endosperm has been removed, leaving only the tough outer covering as bran. The stock which comes from the last pair of rolls and scalper is composed of shredded bran and a mixture of fine flour, fiber, and fluffy material. It is necessary to separate out the bran and to get it sacked and out of the way. This is done in the *bran duster* and the *bran bin*. The bran is used for stock feeding, but modern milling has been able to clean it so effectively of the endosperm, that the bare hulls have little food value. On the other hand a greater amount of flour is recovered to-day than by former processes.

The bran having been eliminated there now remains the chop, so-called, to be dealt with. This consists of germ, semolina or large flakes of endosperm, middlings or medium sized flakes, dust or very fine middlings, and various small fibrous impurities. The first and last of these must be eliminated altogether; the oils of the germ will give the flour a dark color if it is left in, and the flour will have a tendency to become rancid if kept too long. The chop is therefore sent to a *grading reel* for grading or grouping the stock before it is sent to the purifier. This brings us to the fundamental process in milling, namely the reduction of the middlings or flour milling proper; in this process there are three principal machines: the purifier, the smooth roller or pulverizer, and the bolter.

Purification. — As just noted there still remains, mixed with the flakes of endosperm, a quantity of dust and fibrous material, which would impair the quality and value of the flour if not removed. This is got rid of in the *purifier*, which is a machine complicated in structure but simple in principle. The process of purification is affected by the application of air currents and of sifting. The middlings are fed into the machine from above onto a series of sieves through which currents of air are blowing. The sieves sift and grade the particles by size; at the same time the force of the air currents blows off the dust and shreds of bran, which are lighter. Again gravity is called to the miller's aid. The process of purification is very important, for this is practically the last opportunity to get rid of impurities, which would be ground up with the flour if they went to the reduction rolls and would contaminate it and lessen its value.

The dust which is blown off in the purifier is collected in a *dust collector*. As a matter of fact a well-equipped mill has exhaust fans and other devices to carry off the dust at every practicable stage. This is the most important one in the series, however.

Reduction. — Now at last we reach, nearly at the end of our journey, the flour making section proper. All that has gone before has been merely to prepare the stock, so that the resulting flour should be free from impurities, of uniform quality, and of the right color, gluten content, etc. Reduction or grinding is done by sets of rolls, as was the breaking process, but now the rolls are smooth instead of being corrugated. The sets of rolls form a series, each succeeding set having the rollers set a little closer together and therefore grinding a little finer. There may be as many as a dozen reductions, though the average mill would not have so many. The product of the reduction rolls is flour, but it must be sifted and refined still further.

Grinding Room in the Pillsbury Mill

This shows a section of the grinding room. Notice the complete absence of workmen.

Bolting. — Following each set of reduction rolls is a flour *bolter,* which is a huge machine containing a large number of sieves made of silk bolting cloth of varying mesh. The ground flour, now a fine, almost impalpable dust, is shaken and sifted through this cloth by means of a dizzying side motion. One visitor to a large Minneapolis mill described the bolting room as follows: "All around him dance huge, amorphous things, with multitudinous legs, breathing fine white dust. Some are round, some square, and they dance and dance and dance to the music of their own rattling, a portentous shimmy of giants. . . . You are told that their function is to sift, but you know perfectly well that their business is to dance this devil's hornpipe, up there all by themselves, with nobody watching them."[1]

The fine bolted flour is now ready to be conveyed to the packing bins, but the coarser parts which did not pass through the bolting cloth are sent back to the purifier and reduction rolls repeatedly, until all the flour possible has been extracted. So keen is the demand for a pure white flour that the best flour is often bleached to remove the yellow or darker tints. *Bleaching* is effected by spraying the flour with air containing nitrogen peroxide, or, better yet, with pure electrified air. There are also several other bleaching processes quite extensively used in this country.

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[1] Bellows, H. A. *A Short History of Flour Milling* (Minneapolis, 1924), p. 45.

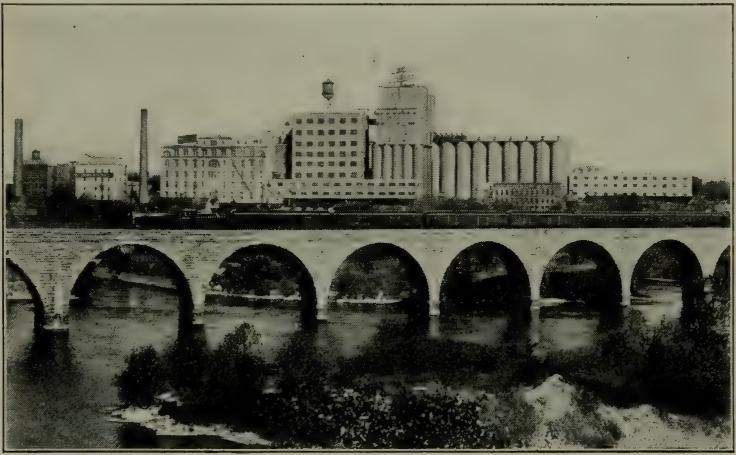
The flour is now ready to be barreled, or, as is the more usual practice, to be sacked. The cut shows the flour being drawn by automatic power packers from a *flour bin* into barrels, which are then ready to be shipped away in railroad cars. There are many such bins, each containing a different grade of flour. When the flour is sacked on an upper floor, as it may be after being bolted, it is usually lowered by some kind of *sack shoot,* which makes unnecessary their handling by workmen. The sacks are automatically filled and tied.

Before the introduction of the roller process of milling flour, it was very difficult to make good flour out of hard wheat, as the brittle bran coat became mingled with the endosperm and could not be bolted out. The resulting flour was dark colored and inferior to that made from soft winter wheat, the bran coat of which is tougher and could therefore be separated better from the endosperm. Hard wheat sometimes sold for 20 cents a bushel less than soft wheat, and the flour made from it commanded a proportionately lower price.

With the introduction of the gradual reduction process, however, the positions of the two wheats have been reversed: hard wheat now commands a higher price and high grade patent flour, made from it, is the best flour sold. This accounts in large measure for the development of the spring wheat district of Minnesota and the Dakotas in the eighties and nineties, and for the rise of Minneapolis as the leading milling center of the United States.

By-products of milling. — The parts of the wheat which can not be utilized for flour, and which have been separated out by the various screenings and boltings, consist of bran, the germ, and a low grade flour. The two latter products mixed together are known as shorts. Sometimes these are mixed with the bran. They are all used as stock feed. In this respect the milling industry has solved the problem of utilizing the by-products better than has the wheat growing industry, for no use has yet been found for the vast quantities of wheat straw which constitute the waste product of raising the grain.

Characteristic features of milling. — One of the most striking features of modern milling is the large use made of natural forces. In the numerous operations which have been described the miller has two main purposes: to separate the endosperm consisting chiefly of starch cells and proteins from all other matter, and to grind these substances into flour. For the accomplishment of these ends he utilizes air, water, heat, gravity, and power among natural forces, while his principal mechanical aids are rolls and sieves. A distinction has often been made between agriculture on the one hand and manufactures on the other, and it has been stated by some writers that in agriculture the farmer depends upon and obtains the coöperation of nature in a greater degree than does the manufacturer in industry, who depends more upon the coöperation of his labor with machinery. Such a distinction is untenable, for in all manufacturing the coöperation of nature[2] and of nat-



PILLSBURY "A" MILL

This is the largest flour mill in the world, and is located at Minneapolis, Minn.

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[2] This term is used loosely by such writers to mean at one moment the life-giving or germinating power of nature and at the next moment the other forces such as gravity, expansion, etc. Only in the former sense is it true that nature coöperates more with agriculture.

ural forces is enlisted, as is well illustrated in the milling industry. The great difference between the two kinds of industry is time, which is under better control, so to speak, in manufacturing than in agriculture. Natural processes can be speeded up and results achieved more quickly. Thus the bleaching or whitening of dark flour will take place naturally in a few weeks, but by spraying the flour with electrified air it is accomplished in a few minutes.

Another noticeable feature is what is called flow-sheet design, that is the planning of the mill and the arrangement of processes and machines in such an order that the material will travel forward through the mill in a continuous course with no wasteful rehandling or return. This is a feature common to many modern industries, but it is carried out to the greatest possible extent in milling. Especial use is made of water power for lifting and of gravity for lowering material. Modern milling is really one continuous process, and the material flows automatically from one machine to another.

This suggests another point, namely the large extent to which automatic machinery is employed. " Where are the men? " is said to be almost invariably the first exclamation of a visitor to a flour mill. An oiler hidden between the close packed machines, a sweeper or two, and once in a while a white-coated miller who opens a window in a machine and closes it again — these are the only persons in sight. There are no rows of operatives at their benches or machines. Probably no product involves the direct application of human labor in a smaller degree than does the making of bread, from the first planting of the wheat, through the milling of the flour to the final process of baking. Machinery is utilized at every turn, and wherever possible it is automatic machinery.

Since so little labor is used directly there do not prevail the minute specialization and division of labor which may be found in some other manufacturing industries, which are described in other chapters. Here the specialization is of machines, each of which is designed to perform one particular piece of work.

On the other hand, there must exist the greatest possible degree of coördination and coöperation among the different machines and processes. A modern automatic flour mill is, in practice, one huge machine, of which each individual appliance is a unit or part. The successful operation of each machine depends on the satisfactory working of those before it. Thus, if the reduction rollers are not grinding good flour it may be because the break rolls, or the scalpers, or the purifiers have failed to perform their parts well. Only if all work harmoniously together, will the final product be satisfactory.

SUGGESTIVE QUESTIONS

1. Name industries in which all three types of manufactures are brought under one control.
2. Turn to the table on flour milling in Chapter XXVIII and determine why the number of wage-earners and the amount of capital per establishment are so small as compared with the other industries given.
3. Why is the consumption of wheat per capita greater in the major countries of Europe than in the United States?
4. What has caused the consumption of wheat per capita to decline in the United States?
5. Make an enlarged drawing of a grain of wheat, showing the different parts.
6. How did the introduction of the gradual reduction process affect the wheat growing industry of the United States?
7. Why has the name " elevator " been given to the buildings where grain is purchased from the farmer?
8. Make a chart showing all of the operations involved in the milling of wheat. Describe each operation briefly.
9. Have you ever seen a sack of flour that would not make good bread? What was wrong with the flour?
10. Have you ever seen the screw-conveyor on a threshing machine? If so, describe its work.
11. Can you think of another industry in which machinery performs so much and human hands so little of the work?
12. Why is it possible to use machinery for so much of the work in flour milling?
13. How do you explain the rise of Minneapolis as the center of the American milling industry?
14. Ask your mother whether she gets the best results if she uses the same flour for pies or biscuits as for bread.
15. On an outline map show the wheat flour zone of the United States by coloring all states producing over 1,000,000 barrels of flour in a year, distinguishing hard and soft wheat areas by different colors. Mark by crosses all important milling centers.

BIBLIOGRAPHICAL NOTE

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CHAPTER XXXI

MEAT PACKING

Characteristic features of the meat packing industry. — In the milling industry the most striking feature was the large use of automatic machinery. In this respect the beef packing industry offers a sharp contrast, for, outside of the by-products departments, there is a surprising scarcity of automatic equipment. Human skill, highly specialized in many directions, takes the place of machinery. In pork packing, however, much greater use is made of machinery.

In another respect, too, the meat packing industry presents a marked contrast with milling, and that is in the utilization of by-products. As we have just seen, the by-products of flour milling are few in number and of minor importance in value, and are utilized in the form in which they come from the mill. The by-products from meat packing, on the other hand, make up a large proportion of the original raw material, both in quantity and value, and utilization in many forms of what was formerly regarded as waste constitutes one of the romantic chapters of modern industry.

Meat packing is purely a transforming industry, so far as the transformation of the live animal into various edible meat products is concerned; but that part of it which has to do with the utilization of the by-products is both a transforming and a chemical manufacturing industry,[1] for some of the resultant products, like soap, are wholly different in kind from the original raw material. It is exactly the opposite of an assembling industry, for it breaks the raw material up into various parts each of which becomes a special product.

For three reasons it seems desirable to study meat packing. First, because it possesses certain characteristic features which differentiate it from the other manufacturing industries which we shall study, and it may be regarded as typical of quite a group. Second, because we have already traced the breeding and raising of beef cattle on the farm, and this chapter will serve to carry on that story to completion. And third, because meat packing is one of the most important manufacturing industries in the United States to-day, ranking first in value of products according to the census of 1920. This chapter will be confined to the packing of beef.

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[1] For this distinction, see p. 462.

Development of meat packing. — Before the modern packing house was established the usual method was to drive livestock to the point of consumption, or to ship them by car, and they were then slaughtered and put on the market by local butchers. The first step in the concentration of the business at a few points near the source of raw materials was taken when Cincinnati became the first important pork packing center in the country in 1860. At that time, owing to the lack of refrigerating processes, meat could not be shipped long distances unless it was first cured or salted. It was therefore the practice to salt the pork down and pack it into barrels, from which came the name " packing industry," a name which to-day is really not descriptive of modern processes in slaughtering and meat packing, and might better be applied to an industry in which the product is packed in containers, like fruit and vegetable canning. But as it is used to designate this business, it will be so employed in this chapter.

The significance of this concentration of the business lay in the fact that now the livestock began to be shipped to a few central points, where it was converted into dressed meats, which were shipped to the consumers in eastern markets. This was much more economical, for now it was not necessary to pay freight on the waste products of the live animal, but only on the dressed beef, which makes up only about 54 per cent of a beef animal. The other 46 per cent remained in the packing house to be worked up into other articles or to disappear as waste. With the invention of refrigerator cars about 1870 a great impetus was given to the development of meat packing companies in Chicago and other mid-western cities. As cattle raising spread farther west, where they could be raised more cheaply than in the East, additional packing centers grew up, such as St. Paul, Omaha, Sioux City, St. Louis, Kansas City, Denver, Oklahoma City, and Fort Worth. There has been a strong tendency to limit the number of centers and also of separate companies and plants, in order to obtain the advantages of large scale operation. A well organized plant must have a steady supply of raw material or live stock, and hence too great a multiplication of packing plants would be uneconomical.

A modern packing plant. — It has been said that the heart of the modern packing industry is the refrigeration plant and the lungs are the power plant. Both of these exist, however, to give life to the processing department, which consists of an abattoir building where slaughtering, cutting, etc., are carried on, a cooling building, a rendering building, a manufacturing building, and perhaps still others in a large concern. In one large packing company in Chicago there are seventy-one distinct branches. The various processes can be understood most clearly by following a beef animal through the plant, from the time it is received in the pen until the various products into which it has been separated are shipped out to consumers. The operations in a large Chicago packing plant are selected as typical of the best practices. Only general practices can be described, however, because there is considerable difference in detail among various companies, but the main outlines are the same in all.

UNION STOCK YARDS, CHICAGO

The union stock yards and packing houses cover 500 acres and furnish employment to over 50,000 people. During the year 1925 there were received here 3,023,387 cattle, 847,762 calves, 7,995,964 hogs, and 3,968,670 sheep. The illustration shows the cattle pens, which are all paved and contain feeding and watering troughs, and also the runways along which the animals are conducted to the packing house which has bought them for slaughtering purposes.

The Chicago Stock Yards. — The cattle which are destined for any one of the great Chicago packing plants are shipped to the Union Stock Yard and Transit Company, which is a great live stock market distinct from the packing houses. It covers an area of approximately three quarters of a square mile, divided into numerous pens, each of which is paved and contains feeding and watering troughs. The live stock usually arrives at the Yard in the night or early morning, often after a long hard ride of hundreds of miles, the average for beef cattle being nearly 700 miles. The long journey excites and exhausts the cattle so much that a period, generally of about twenty-four hours, is given to allow them to become quiet and rested.

The scene in the Stock Yards is a bewildering one. On every hand are pens, viaducts, and buildings, and noise and confusion seem to reign everywhere. The deep lowing of the cattle and the calls of the drovers are heard constantly. But the apparent confusion is well ordered, and an enormous number of animals is handled daily with ease and quickness. It is in the Stock Yards that the cattle are bought by buyers of the packing houses. After the deal has been made, the cattle are weighed and are then driven by overhead runways or viaducts, twenty miles of which have been built over the tops of the pens and alleys of the yards, to the packing house where they are to be slaughtered.

Slaughtering cattle. — After the cattle have rested, they are driven up an inclined runway to the top of a four or five story building. This is done for the same reason that the wheat was elevated to the top of the flour mill, in order that gravity may be used to convey the raw material through subsequent processes. There is this difference, however, that the cattle carry themselves to the top of the building, whereas the wheat must be elevated by machinery. Once at the top, the cattle are driven into a long, narrow lane of width sufficient to allow only two cattle to stand abreast. As the two animals in the lead reach the end of the lane, or knocking pen, a partition is lowered behind them. This process is repeated for the next pair, and so on until the lane is full. A man with a sledge hammer then walks along a platform near the top of the lane and stuns each animal by a blow in the center of the forehead. By a mechanical contrivance the side partition of each pen is raised and the floor is tilted sidewise, thus sliding the stunned animals on to the main floor of the slaughter room.

A shackle is quickly placed around the hind legs, and the animal is hoisted and hooked to a rail, along which it slides to the butcher or " sticker," who, with a quick thrust, severs the jugular vein in the neck. This is the actual killing. The blood is carefully collected for future use. Next the head is skinned out and removed, and the carcass is lowered to the floor with the feet up in the air. The fore and hind legs are skinned and detached at the knee joints and sent down a chute to the by-products department. The hide is opened down the center of the belly and the entrails removed, and the carcass is then hooked through the hocks, hoisted, and started on its further journey by an overhead gravity trolley.

Taking off the hide. — In this operation, in the larger establishments, the division of labor is carried to a high degree. Each workman engaged in removing the hide removes only a certain portion, and the amount done by each is surprisingly small, but this is compensated for by the additional quickness which the worker acquires. This aspect of the work has been so well described by Professor John R. Commons [2] that his words are quoted.

" It would be difficult to find another industry where division of labor has been so ingeniously and microscopically worked out. The animal has been surveyed and laid off like a map; and the men have been classified in over thirty specialities and twenty rates of pay, from 16 to 50 cents an hour. The 50 cent man is restricted to using the knife on the most delicate parts of the hide (floorsman) or to using the axe in splitting the backbone (splitter); and, wherever a less skilled man can be slipped in at 18 cents, 18½ cents, 20 cents, 21 cents, 22½ cents, 24 cents, 25 cents and so on, a place is made for him and an occupation mapped out. In working on the hide alone there are nine positions, at eight different rates of pay. A 20 cent man pulls off the tail, a 22½ cent man pounds off another part where the hide separates readily, and the knife of the 40 cent man cuts a different texture and has a different " feel " from that of the 50 cent man. Skill has become specialized to fit the anatomy. . . . Taking a crew of 230 butchers, helpers, and laborers, handling 1050 cattle a day under the union regulations of output, the time required for each bullock is equivalent to 131 minutes for one man, from the pen to the cooler, the hide cellar, and all the other departments to which the animal is distributed . . . making the entire labor cost about 46 cents per bullock."

The preparation of hides. — At this point we may leave the beef carcass and follow the hides while they are being prepared for the market. No packing houses tan the hides, but merely prepare them for sale to tanners, but this is an important branch since the hides rank next in value to the beef itself. The " take-off " of the hides must be carefully watched to see that no cuts are made in them, as this lessens their value. They must also be kept as clean and dry as possible during the process of skinning, and stored in a moist cellar with little circulation of air. The hides are graded according to weight, the presence of brands, cuts and scores, and other similar characteristics. After this has been done hides of the same grade are built in packs with layers of salt in between, and left to cure or absorb the salt for from twenty-five to thirty days. At the end of this period, during which they have shrunk about 15 per cent, they are ready for shipment.

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[2] " Labor Conditions in Meat Packing and the Recent Strike," in *Quarterly Journal of Economics.* Vol. XIX (November, 1904), p. 3.

Splitting and washing. — We may now return to follow the carcass as it moves along the overhead rail, usually propelled by an endless chain in the larger packing plants. The backbone is split throughout its entire length with a saw and a sharp splitting cleaver, and the carcass is divided into two halves or sides. These are scrubbed, usually with a fountain brush through which a stream of fresh warm water passes, and the meat thoroughly cleansed. The sides of beef are also held under an automatic sprinkler, which rinses them thoroughly. They then pass into the hands of wipers, who dry them with towels kept clean by improved sanitary washers. From the dryers the meat passes to the cooling and refrigeration rooms.

Beef cooling. — The sides are kept in the coolers for from one to three days, according to size, in a temperature of about 38° F., in order to remove all the natural animal heat. The meat is not frozen in the coolers but is thoroughly chilled. With the present methods of artificial refrigeration by the use of ammonia the temperatures can be accurately controlled at the desired point. From about 1865 to 1880, the method of refrigeration was by a huge ice-box, containing natural ice, above the cooling room, so that this resembled a great domestic refrigerator. To-day, most of the large plants have the brine spray system, by which a continuous flow of salt water, chilled by contact with pipes containing ammonia gas, is sprayed in an air chamber directly above the cooling rooms, thus maintaining an even temperature and the necessary moisture. By mechanical refrigeration the time required to chill dressed carcasses properly has been reduced by one-third to one-half below that required by the natural ice method.

Refrigeration or cold storage rooms are used for storing or holding meats after they have been cooled and before they are sold. Usually they do not remain in cold storage over two weeks. Since the pure food laws prohibit the use of borax, boracic acid, or other chemical preservatives, the packers are dependent solely upon refrigeration for keeping the meats fresh, and consequently careful attention is given to this branch. Not over three per cent of the meat is frozen and sold as frozen meat.

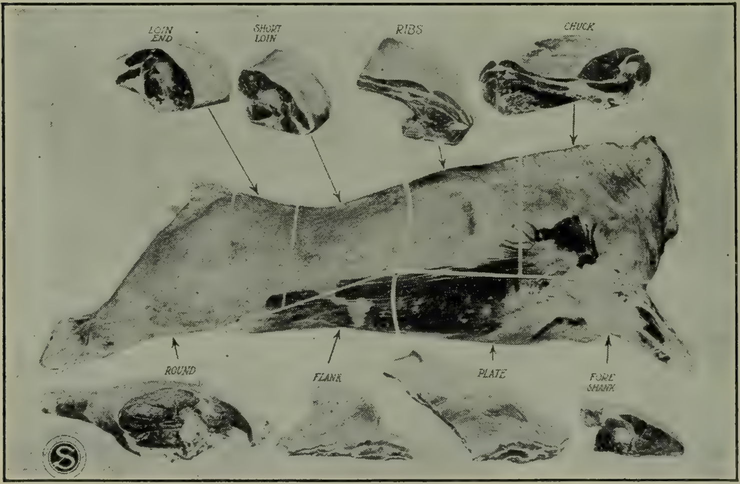
Beef Cooler

This picture shows an aisle and two rows of beef in the main cooler of a large Chicago meat packing plant. The meat in such a cooler is chilled but not frozen, as the temperature is several degrees above freezing, and is not kept here longer than two weeks.

If the sides are to go into the market as fresh beef they are loaded into refrigerator cars, which have been thoroughly chilled in advance and are kept so during the journey, and are shipped to distributing houses or to retailers, who cut the beef into pieces to suit the taste of the customers. Ninety per cent of the beef is marketed in the fresh form.

On the cutting floor. — If the meat is to go to market in some other form than as fresh beef, the carcasses are taken from the cooler to the cutting floor, where they are divided into different cuts. The sides are run on to the cutting floor suspended from the overhead rail, and are quartered as they hang by a man who passes his knife between the ribs and the loin. The two quarters are placed on moving tables which carry them past a gang of butchers, of whom one cuts the kidney and another the flank from the hind quarter and a third cuts the shank from the fore quarter, while a fourth separates the kidney from the fat in which it is imbedded.

The moving tables carry the various cuts to mechanical band saws, by means of which the bone is cut from the rump, the ribs and navel end are separated from the chuck, and the brisket and chucks are themselves cut asunder. Frequently the meat is boned, that is to say the bones are removed and the meat is rolled and tied; such cuts are in demand in hotels and restaurants as much of the labor of carving is thereby saved. Most of the boned meat, however, goes to the canning and sausage departments. The same minute division of labor exists on the cutting floor as in the abattoir, and the men employed in cutting and boning are highly specialized and skilled.



Standard Beef Cuts — Chicago Style

This diagram shows the various cuts obtained from a side of beef. The average steer, weighing 1000 pounds alive, will yield only about 550 pounds of meat, of which about 144 pounds or one-fourth of the dressed weight comprise sirloin and porterhouse steaks or rib roasts.

There is considerable waste in these operations in the form of bones and bone sawdust which gathers under the band saw. These are all gathered up, however, and sent down chutes to the proper departments. From the best bones knife handles and other articles are made, while the poorer bones and bone sawdust yield glue, tallow, poultry and livestock feed, and fertilizer material.

Canning and curing. — The meat used in canning is usually cow beef or those parts of the steer which are not in demand as fresh beef. Meat which is to be canned is first sent to the " cook room " where it is partially cooked in great kettles of galvanized iron, during which process it loses about one-third of its weight. From the kettles the meat is conveyed by a movable carrier to the trimming table, where all superfluous gristle, fat, skin, and connective tissue are removed, to be converted later into grease, fertilizer, and poultry and livestock feed. The trimmed meat is sent down metal chutes to the stuffing floor, where it is pressed into cans, which are capped, soldered, sealed, and inspected by steaming to ascertain if any air holes exist. Canned meats are preserved by sterilization and exclusion of the air, so that the slightest leak would spoil the meat. The cans are then thoroughly sterilized and the meat further cooked under steam pressure at 250° F. By this process the cans are made immune from all climatic changes and can be shipped to any part of the globe. Canned meats reach the consumer in the form of tongues, corned beef, corned beef hash, mess beef, and similar articles.

Some of the meats just mentioned are cured before they are canned, and a word must be devoted to this process. Curing is very simple and consists merely in immersing the beef in a pickle; if corned beef or dried beef is to be made this pickle is composed of sugar, salt, and saltpeter or nitrate of soda, but for mess beef a pickle of plain brine and saltpeter is usual. The meat is kept in the pickle a variable length of time, depending upon the weight of the meat, the temperature, and other factors, but usually about four weeks. About 4 per cent of the beef comes on the market as canned beef; and another 3 per cent is cured.

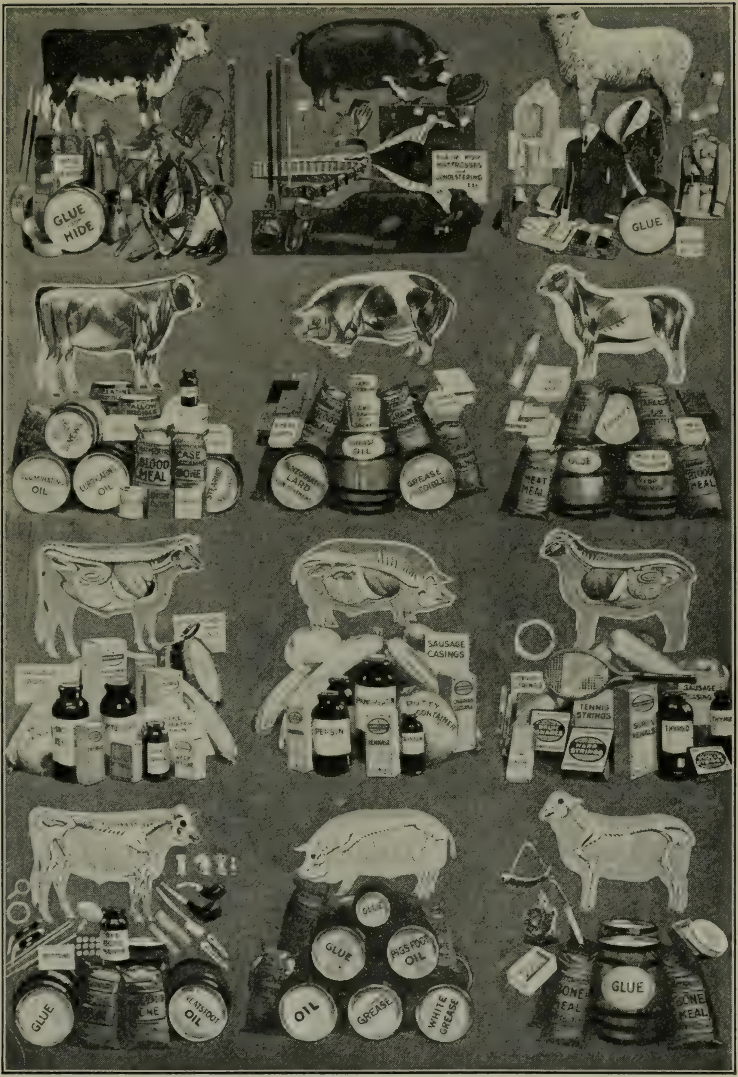
By-products. — An average steer will yield about 54 per cent of its live weight in dressed beef, and about 6 per cent for the hide, leaving some 40 per cent to be accounted for in the by-products and shrinkage. These by-products exist in the form of edible meats, such as tongue, brain, heart, sweetbreads, tripe, and other

" fancy meats " which need not be described further; of oleo oil, stearin, tallow, and grease; of blood and tankage; of sausage casings; of hoofs, bones, and horns; of hair and switch; and of glands and sinews for pharmaceutical purposes. The saving and utilization of these products, which were formerly regarded as waste and still are so treated by the local butcher, constitutes one of the most interesting chapters in the history of meat packing. The residue of valueless material amounts to-day to only about 10 per cent; to this must be added, however, another 20 per cent for shrinkage and evaporation in estimating the proportion of the live animal which is utilized.

There had always been certain by-products in the meat packing industry, as lard, tallow, soap, glue, and fertilizer, but it was not until the introduction of refrigeration in the seventies that it became possible to save the more important waste products for a sufficient length of time to utilize them. The real development came in the eighties when chemists began to be employed to make a scientific study of the problems involved, and to devise methods for the better utilization of by-products. Since then the progress of these branches of the industry has been very rapid. The products which formerly occasioned considerable expense to dispose of, are now the source of even greater profits. And the utilization of the by-products has at the same time made it possible to sell the fresh beef at a lower price, because some of the costs of production are borne by these articles.

The table on the opposite page shows the principal by-products.

Oleo products. — The most valuable by-product of slaughtered cattle is the hides, but next to them come fats. Prior to the Franco-Prussian War, in 1871, fats were used almost exclusively for soap making and other manufacturing purposes, but during the siege of Paris a reward was offered for a substitute for butter and a French scientist succeeded in producing such a substitute from beef fat and at a lower price. This product he named oleomargarine. It was introduced into the United States about 1873, since when its production has steadily increased, amounting in 1920 to 370,730,000 pounds. Over three quarters of the oleo oil produced here is, however, exported to Holland, where it is made into butterine and distributed throughout Europe and England. It seems better suited to the taste and purses of consumers in those countries than in the United States.



BY-PRODUCTS IN THE PACKING INDUSTRY

This illustration shows clearly the various by-products obtained from different parts of a beef steer, a hog, and a sheep.

The fats used for the manufacture of oleo oil may be all the fats removed when the animal is slaughtered, but in practice the damaged or dirty fats are used for tallow. The fats are washed as soon as removed from the animal and thoroughly chilled. They are then chopped into small pieces and melted in a huge kettle, from which the liquid oil is run off to a clarifier or settling kettle. Here the sediment collects at the bottom and is drawn off, the nearly pure oil being finally strained to the seeding or graining trucks where it is mixed with salt and is finally pressed through cotton canvas cloths. The fine oil obtained is oleo oil; the product left in the cloths after pressing the stock is stearine, and is used principally for the manufacture of compound lard. The sediment and scrap collected during the manufacture of the oil are sent to the tank house for use as fertilizers. The oleo oil is mixed with neutral lard, vegetable oils, and milk and made into oleomargarine by a process resembling butter making.

All fats coming from the beef department which are not utilized for oleo are made into tallow. The process is similar to that employed in making oleo; the refined tallow is used for soap and the residue constitutes a low grade brown grease for lubricating purposes or for fertilizer.

Tankage and fertilizers. — Until about 1870 the waste water, blood, and other liquid refuse from slaughtering had been turned into the sewers, but it was then discovered that these contained nitrogen, phosphorus, calcium, and other elements of value as stock food or fertilizer. To-day practically all of these by-products are recovered.

We have seen that in the processes of slaughtering, cutting, and canning a great deal of water has been used for washing and cooking, and that various residues and sediments have been produced. In a large modern plant most of these have been collecting in the tank house for further utilization. The matter other than water is first graded and then placed in a rendering tank or " digester " where it is cooked for eight to ten hours by steam under pressure, at the end of which time the contents of the tank are allowed to settle. These have now separated into three parts: (1) the oil, (2) the semi-solid residue, and (3) the water. The oil, which floats on the top, is drawn off and further processed by methods similar to those just described for oleo oil; the product is a tallow which is graded into white grease, yellow grease, and brown grease, and is used for making soap, lubricants, and similar articles.

After the oil has been drawn off the top, and the water drained off at the bottom, the remaining contents of the tank are dropped into shallow boxes lined with press cloths which are folded over the top. Ten or twelve of these cakes, one on top of the other, are then placed in a press and reduced to about half their size. The grease which is squeezed out is sent back to the rendering tank, and the remaining concentrated tankage or " stick " is used for fertilizer or poultry and stock feed after being mixed with certain other ingredients.

The water which remains from these processes, as well as that coming from other parts of the plant and containing more than a certain proportion of solids, is run down through pipes to an evaporating tank. Attention has already been called to the large use made of the force of gravity, which is utilized at every stage to avoid handling and trucking; but at this point the application of another principle of physics may be noted. This is the fact that as atmospheric pressure is reduced the amount of heat necessary to produce boiling is lowered. For example, water at ordinary atmospheric pressure and at sea level boils at 212° F., but water under a twenty-eight inch vacuum will boil at 100° F. Taking advantage of this fact a considerable economy in coal is effected by evaporating the tank water in a vacuum. After the water has been evaporated the semi-solid residue or " tankage " is dried and used as fertilizer or for feeding.

There is one other source of fertilizer, and that is the blood. After being collected (p. 456) it is pumped to receiving tanks where it is slowly baked, by which process it is coagulated in large grains. The mass is then pressed and dried in the same manner as tankage, and the solid product is sold as dried blood or mixed with dried tankage to form fertilizer.

Other by-products. — As the preparation of the other by-products is conducted in essentially the same manner as those already described, by cooking, separating, drying, pressing, and in the case of certain bones by grinding, it is not necessary to describe these in detail. A few of the more important products may, however, be mentioned. The intestines are used as sausage casings, gas cells in dirigible balloons, etc., and the sinews as surgical ligatures and as strings for various musical instruments. Bones of the harder kind are made into manufacturing stock, which is sold to makers of buttons, combs, bone handles, and similar articles. Other bones are usually ground and used for the manufacture of tallow, of glue, and of bonemeal. Each of these has various uses which do not need further description. Horns and hoofs are also used for making buttons, combs, handles, etc., but the demand for these has greatly lessened owing to the use of cheaper substitutes. From the feet, after the hoofs are removed, are obtained principally neatsfoot oil, glue, and fertilizer. The hair and switch are used for making various kinds of brushes and for upholstering furniture. And finally, nearly fifty medical and pharmaceutical preparations are made from the glands and membranes of animals slaughtered, among the more familiar of which are pepsin, pancreatin, thyroids, rennet, and suprarenalin.

In connection with the manufacture of all these by-products there have been established in the larger plants chemical laboratories, and for handling all the products auxiliary plants have sometimes grown up. Such are the tin shops where the cans are made, the box factory where boxes are manufactured, and the car shops where refrigerator cars are built and repaired.

General conclusions. — In spite of, or rather because of, the nature of the materials which are handled in a packing plant the utmost efforts are made to ensure cleanliness. Not only are the meats scrubbed and cleaned, but the walls and floors, and all the tools and equipments are washed and sterilized frequently. The consumption of water in a large plant will amount to several thousand gallons every hour. Many of the larger packers maintain laundries and furnish the workmen clean outer garments daily, and some establishments even employ manicurists to treat regularly the nails of workers handling such products as chipped beef. It was early discovered that sanitation was good business, but the knowledge was translated into effective practice only after Federal inspection of meat packing was established in 1891, and especially after the comprehensive law of 1906.

Another discovery which came comparatively late in the industry was the intimate connection between efficient production and science. The simple physical principle of gravitation was early applied in the plant layout; somewhat later came such economies as boiling in a vacuum. The effects of refrigeration in preventing the development of bacteria were applied in the seventies. But it was not until the eighties that the aid of chemistry was invoked to control the chemical processes of manufacture and to devise methods for utilizing the by-products. To-day there is scarcely any industry in which the dependence upon science is closer than in the meat packing industry.

The most striking economic characteristics of meat packing are specialization, standardization, and large scale production. A local butcher may perform all the operations involved, from the knocking pen to the retailing of the dressed meat, but does all less efficiently. In a large plant the division of operations among a number of men led to proficiency in one line, and was the first step toward specialization or division of labor. In most mechanical industries the splitting up of a process into a number of simple repetitive operations of a routine character has usually led to the invention and introduction of labor-saving machines (see Chapter XXVIII). Not so, however, in the meat packing industry, where the specialization has to a considerable extent remained one of skill, and in which human labor has been only partially replaced with specialized machinery.

An increasing tendency toward the standardization of equipment and practices is noticeable among the various packing houses. This has been greatly hastened by the establishment of standards in connection with the Federal inspection carried on by the Bureau of Animal Industry of the United States Department of Agriculture, and by the regulations regarding the sale of meats issued by the Chicago Board of Trade. The period of experimentation in this industry seems to have passed, and it has now reached a stage of careful utilization and improvement of existing practices.

Perhaps the most obvious fact which this brief survey has brought out is that the economies of large scale production are realized in meat packing as in few other industries. This is most strikingly illustrated in the utilization by the large plants of the by-products which it would not pay a small concern to save. In this fact lies the main explanation of the growth of the large packing houses in the United States.

SUGGESTIVE QUESTIONS

1. Why is it not possible to use machinery as extensively in meat packing as in the milling industry?
2. Does your local butcher operate a small slaughter house? Why, or why not, as the case may be?

3. Why has the packing industry tended to move westward?

4. Why are the slaughter houses not located at points near the western ranges where the cattle are pastured?

5. Draw a chart showing the route of a beef animal from the time it leaves the stock yards until the different beef products obtained from it are ready to be marketed.

6. In the Chicago Stock Yards one sees a number of men riding horses into and out of the different pens of cattle. What are these men doing?

7. What kinds of work in the preparation of a beef animal require the highest pay?

8. How are refrigerator cars kept cool?

9. Locate the different cuts of beef on a diagram of a beef animal.

10. What is done with the cattle which are not fat when they are sent to the Stock Yards?

11. Why can a local butcher not afford to save the by-products of beef?

12. Can you distinguish between butter and oleomargarine? What is the difference?

13. What is meat meal?

14. What is done with the hides?

15. The sides of beef, which your local butcher may receive from a Chicago or other packing house, are stamped by a government inspector. Why?

BIBLIOGRAPHICAL NOTE

The most comprehensive book on meat packing is *The Packers' Encyclopedia* (Chicago, 1922), edited by P. I. Aldrich. Other good books, descriptive of the industrial processes, are R. A. Clemen, *The American Livestock and Meat Industry* (New York, 1923); W. H. Tomhave, *Meats and Meat Products* (Philadelphia, 1925); and F. W. Wilder and D. I. Davis, *The Modern Packing House* (Chicago, 1921). Another good book, sponsored by the packers themselves, is *The Packing Industry* (University of Chicago Press, 1924), a series of lectures by various speakers. A less friendly point of view is presented by C. E. Russell, *The Greatest Trust in the World* (New York, 1905). This was based largely on the findings of the Commissioner of Corporations in his *Report on the Beef Industry* (Washington, 1905). Another government publication, dealing with the labor conditions in this industry, is *Wages and Hours of Labor in the Slaughtering and Meat-Packing Industry, 1917,* Bulletin 252 of the Bureau of Labor Statistics of the United States Department of Labor (Washington, 1919).

CHAPTER XXXII

PAPER

Next to the invention of language itself, the development of the art of printing has probably been of greatest importance in contributing to the progress and enlightenment of the world. But the art of printing would be of little significance in so far as general utility is concerned, unless the invention and improvement of processes in the manufacture of paper had at the same time made available a supply of cheap material for printing. The influence of these things can hardly be over estimated. Printing has brought about and facilitated the recording, accumulation, and diffusion of knowledge. If there were no printed matter handed down from one generation to another, but little progress would be made. Each succeeding generation, instead of starting where the preceding one stopped, would have to go back to the beginning. But books give to later generations all of the discoveries of the earlier ones. They do not have to work these out for themselves. They, therefore, have time left for making new discoveries which will lead to further progress. The process is cumulative.

The consumption of paper is often claimed to be the true measure of a people's culture and learning. While this will not apply in all cases to present-day consumption, yet it may be said in a general way of the different countries of the world that those with the highest degree of development are the ones which consume the largest amounts of paper. In the history of most countries one would also find that progress and increased consumption of paper have gone hand in hand. The per capita consumption of paper in 1920 in the United States was 148 pounds, in Great Britain 75 pounds, in Germany 43 pounds, in Scandinavia 33 pounds, in Japan 11 pounds, and in Russia 5 pounds. The examples of the United States and Russia illustrate well the above statement. The one is a progressive country with the majority of the people having a fair education, the other a backward nation of illiterate people. Or the progress of one country may be estimated by comparing different periods; thus at the time of the Revolutionary

War there were in the United States 37 newspapers with a combined circulation of 48,000; to-day there are over 20,000 daily papers with a total circulation of over 30,000,000.

The amount of paper used by the modern newspaper is almost incredible, that necessary for the Sunday edition of a metropolitan paper of 18 sheets being about 168 tons or enough to fill five ordinary freight cars. A single large New York newspaper uses up nearly 2000 acres of forest a year, or seven to eight acres a day. Paper made from wood pulp does not last, but that is of no great moment since most of the matter printed in the modern newspaper, by which the majority of the cheap newsprint is used, has no permanent value.

What is paper? — If you tear a sheet of paper and examine the torn edges you will find some small, hair-like particles projecting from the edges. These are the fibers from which all papers are made. Paper consists of a tangled web of these minute fibers, matted and interwoven so that they form an unbroken whole. In a sheet of paper the size of this page which you are reading there are about six million fragments of fibers.

Paper can be made of practically any fibrous material, and has been so made for some centuries, but a tremendous change in the industry occurred when wood was introduced as a raw material for pulp. In order fully to appreciate the significance of this innovation it is desirable to glance briefly at the early history of paper before describing the modern processes.

Early paper materials and methods of manufacture. — The importance of paper and its contribution to modern civilization becomes evident when we consider the make-shifts to which man resorted before he had discovered this process. The Babylonians used clay tablets for making records; the Greeks and Romans used wax tablets, but these were very perishable. The Egyptians made a true paper out of papyrus, a plant which grows in the swamps along the Nile, but this was fragile and costly. Under the outer skin of this plant are found a number of fibers, which were removed and laid crisscross upon each other to form a sheet. This was moistened with a prepared substance which held the fibers in position, and was then pressed under heavy stones; and the resulting sheet was dried in the sun. This papyrus was manufactured into both sheets and rolls, one roll in the British Museum being 122 feet in length and 2½ feet in width. Parchment, made of the skins of animals like lambs or goats, was very expensive and limited in quantity, and writing by pen was laborious and slow.

Printing seems to have come before paper, for the Romans made type with which to stamp their coins and lead pipe, but without paper it was of no avail for book making. About the beginning of the Christian era the Chinese made paper from pulp, using as materials the inner bark of a tree, pineapple stems, the soft parts of bamboo, and cotton. The knowledge of these processes did not penetrate to Europe, however. In the third century the manufacture of rag paper appeared in China and gradually moved to Europe.

The first paper manufacturing in Europe was carried on by the Moors in Spain, cotton being the material used. Linen was also used by these early paper makers, and because of its firmness and durability made the best grade of paper. During the twelfth century Spain was the greatest paper-making country in Europe, with Italy ranking second. From Spain the industry gradually spread over the rest of Europe. All of this paper was handmade, and, with the slow and laborious processes of manufacture, was produced in limited quantities, although it was of excellent quality. Early in the nineteenth century the invention of the paper machine almost completely elminated handmade paper, and about the middle of the nineteenth century wood was introduced as a source of fibers. These two events, coupled with the use of chemical processes in manufacture, have made available an enormous amount of paper, and have laid the foundation for an industry which is the seventh largest in the United States.

Raw materials of paper manufacture. — The materials which are used in the manufacture of paper may be classified as follows:

1. Seed hairs: the only representative of this class is cotton, whose fibers form the covering of the cotton seed. Cotton usually reaches the paper mill in the form of rags and spinning waste. The short fibers adhering to the seed hulls are also occasionally removed by mechanical processes and used for high class papers.

2. Bast fibers: these are fibers found in the inner bark of various plants, as flax, jute, hemp, ramie, Chuen grass, paper mulberry, and Manila.

3. The leaves and stems of straws and grasses, such as corn, wheat, bamboo, sugar cane, and cotton.

4. Different species of wood, such as spruce, pine, hemlock, and poplar.
5. Peat.
6. Rags and waste paper.

Among all of these materials wood, in the end, is the cheapest. In some cases, the original cost of other raw materials is less and the paper content of the fiber is greater than for wood, but these materials are either so limited in supply or situated so far from centers of consumption that they are of little importance commercially. The cost of paper from cotton linters would be prohibitive. Bast fibers with a few exceptions have uses which are more profitable than for paper and uses which can not be satisfied by such a variety of products as can the demand for paper. But the wastes of other industries using these fibers are used in paper making. Bamboo and mulberry are used primarily in making paper of a good quality in which great strength and durability are necessary; their cost of manufacture is too great, however, for ordinary paper. The wastes of agricultural products have not been economically utilized on a large scale as yet, although there are factories in the grain belt which manufacture pasteboard and cheap grades of wrapping paper from wheat, rye, and oat straw. But with the competition of cheap wood-pulp paper products, the market for these is not wide. Peat has been used in making paper and for some purposes the resulting product is better than other kinds of paper, but here again the competition of other kinds of paper must be met. Peat supplies are not situated close to the large consuming markets nor is the cost of production as low as for some other types. Rags are used when paper of a high quality is desired. Paper waste can be utilized when other paper making materials are remote.

Conditions favorable to the use of wood. — In selecting a site for a pulp and paper mill, the first consideration is a supply of timber sufficient to last for several years. A mill situated near a large forest reserve is in a much better competitive position because of the cost of transporting such bulky articles as logs. There are also advantages in the case of a mill which is so situated that the logs can be floated to the mill by water rather than by shipment over a railroad, as water transportation is much the cheaper. So important is the supply of timber that most paper producers maintain a forestry department in their organization to regulate the use of standing timber and to cultivate a new growth after the old has been cut. The paper manufacturers are one group which is putting the forestry industry, in so far as it affects their welfare, upon a scientific basis.

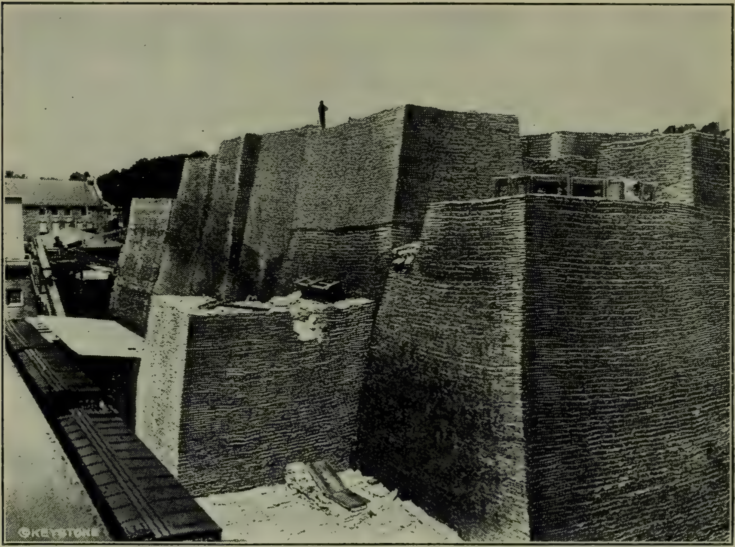
The next important consideration is power. Hydro-electric power and power generated by the burning of coal are used for some of the operations in many of the mills; but the amount of power required, especially in the making of ground pulp, is so great, that practically all mills are located on streams within a suitable forest area where abundant and cheap water-power necessary for the various operations, may be obtained, and where also water for washing and preparing and cooking the pulp for paper is available.

Another factor is the location of the market for the finished paper. Most paper factories are near the raw material, but at the same time they try to get as near the market as possible. The chief centers of consumption are the large cities such as New York, Chicago, Philadelphia, Boston, Baltimore, San Francisco, and Seattle. Most wood pulp is made in New England, New York, and Wisconsin, with smaller amounts on the Pacific Coast.

When one considers the investment necessary to build and equip a complete pulp and paper mill, the importance of these factors becomes more evident. A newsprint mill of 100 tons daily capacity is about the average size. For such a mill, the investment, not including timberlands, is about $5,000,000. To insure a wood supply for a plant of this size requires 100,000 acres, worth $5,000,000, making a total investment of $10,000,000 necessary for a permanent self-contained plant.

Often a paper mill does not complete all of the processes, but relies upon other plants to furnish the wood pulp. In the United States in 1919, there were 729 paper-making establishments. Of this number, 171 were self-contained establishments, 497 made paper only from pulp furnished by another, and 61 made pulp only. The investment for a complete mill averages about two times as much as for those which make either pulp or paper alone.

The processes for making wood pulp and paper: Logging. — The first step in making paper is naturally the cutting of the trees and floating them to the mill. The operations preliminary to these are the construction of camps and of roads and trails through the forest. The trees are cut in the fall and early winter. The felled trees are trimmed, cut into the desired length, and then are dragged by horses on skidways to the main road. Then comes the hauling season when the logs are hauled by horses or tractors on sleighs to loading points on streams or railways. If the logs are floated down a river, they are taken in the spring when the volume of water is greatest. Sometimes much work is done in clearing streams and in building dams for the accumulation of sufficient water when the ordinary flow of a stream is not enough. Often the timber is so far distant that two years and sometimes three or four years are necessary for bringing down one supply of logs. There is a great deal of river driving in all but the Lake states, but here, due to the depletion of the supply of the timber near the streams, railroads are being increasingly used.



A MOUNTAIN OF WOOD PULP

There are 25,000 tons of wood pulp in this pile at Glens Falls, New York, which is an important center of the paper industry.

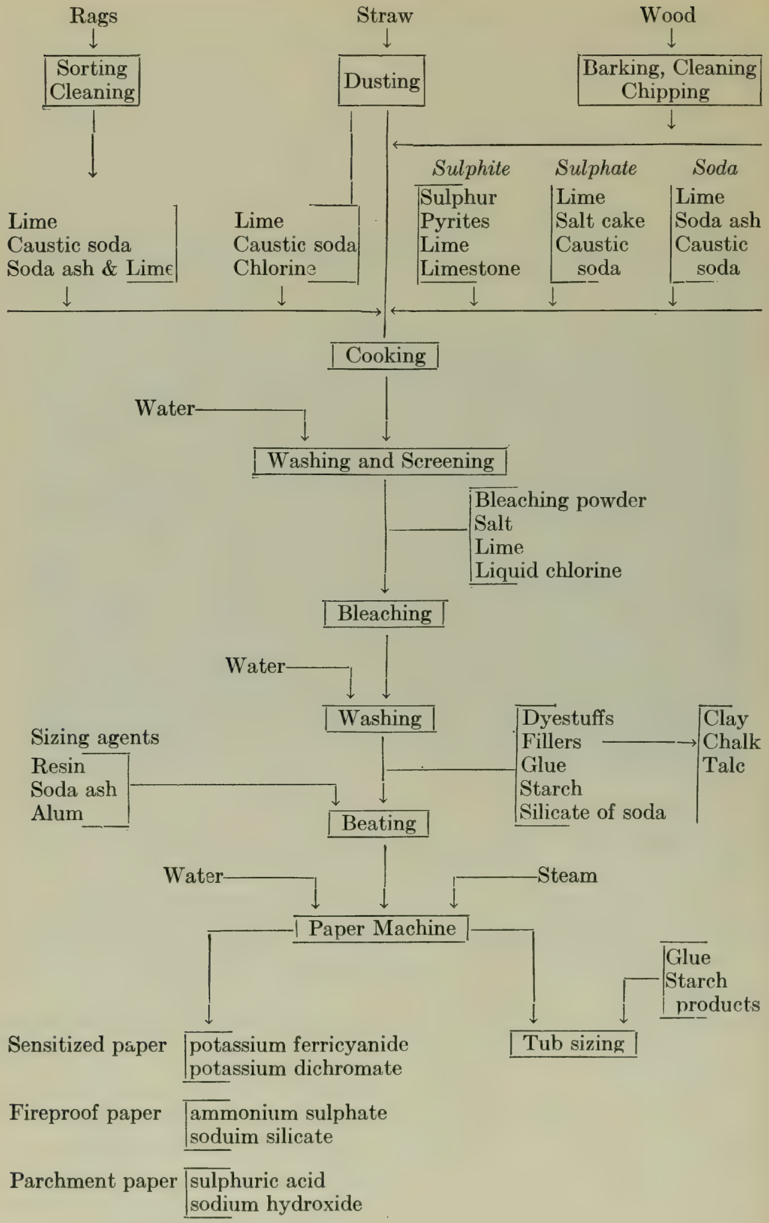
Another method used in carrying logs to the mill is rafting. This is practiced on Lake Superior and on the Pacific Coast. The logs are bound together by chains into large rafts and then are floated in the water to their destination.

Preparation of the logs. — When the logs reach the mill they are not yet ready to be made into wood pulp. The preliminary operations are the removal of the bark and cutting the logs into lengths of about two feet, both of these operations being done largely by machinery. Then all blocks over ten inches in diameter are split into blocks averaging about eight inches in size. If they are to be made into mechanical pulp they are now ready for the grinding mill; but about one-third of them are made into sulphite stock, and these go to machines which break them up into small chips.

Often the removal of bark and cutting up of the logs is done at a plant along the route made especially for the purpose. The prepared pieces are then transported to the pulp mill. This eliminates the transportation to the pulp mill of much waste material.

Kinds of wood pulp. — There are two types of wood pulp: mechanical, made by grinding the wood on a revolving stone in contact with water; and chemical, made by reducing wood chips to a pulp by chemical processes. Chemical pulps are generally stronger because grinding breaks the fibers. In making chemical pulp there are three different processes, the sulphite, the soda, and the sulphate. The pulp is made by cooking the wood in a solution containing the necessary chemicals. Chemical pulp is much more expensive than mechanical pulp, ordinarily being worth from fifty to one hundred per cent more. The increased cost is due to the cost of the chemicals and of raw materials, a cord of wood yielding only half a ton of chemical pulp whereas it yields a ton of mechanical pulp. The chemical processes are not so dependent, however, on cheap water power as is the mechanical.

In the case of mechanical pulp there is little chemistry involved, but in the manufacture of paper by other methods chemical processes are employed at almost every stage. All fibers obtained from any source except rags are known as chemical pulps according to the particular chemical used, as sulphite, sulphate, and soda. The accompanying diagram, from *Chemistry in Industry* (p. 242), " shows the various chemicals used in the different processes and in the stages of pulp and paper manufacture. Reference to it should be of assistance in studying the part which these materials play in the paper industry. It also shows fiber sources, conversion processes, and the principal stages in the preparation of the fiber for the machine, viz., cooking, bleaching, and refining."


Rags
Straw
Wood
Sorting Cleaning
Dusting
Barking, Cleaning Chipping
Sulphite
Sulphate
Soda
Sulphur
Pyrites
Lime
Limestone
Lime
Salt cake
Caustic soda
Lime
Soda ash
Caustic soda
Lime
Caustic soda
Soda ash & Lime
Lime
Caustic soda
Chlorine
Cooking
Water
Washing and Screening
Bleaching powder
Salt
Lime
Liquid chlorine
Bleaching
Water
Washing
Sizing agents
Resin
Soda ash
Alum
Dyestuffs
Fillers
Glue
Starch
Silicate of soda
Clay
Chalk
Talc
Beating
Water
Steam
Paper Machine
Glue
Starch
products
Tub sizing
Sensitized paper
potassium ferricyanide
potassium dichromate
Fireproof paper
ammonium sulphate
soduim silicate
Parchment paper
sulphuric acid
sodium hydroxide

Chemical processes. — Sulphite stock is strong and of good fiber. This process is most widely used, about one-half of the total production being made in this manner. The chief use is for mixing with ground stock, about 20 per cent of the newsprint being sulphite stock, and the remainder being mechanical pulp. It holds the ground pulp together and adds strength to the paper. It is also used in making paper board, writing and wrapping paper, absorbent cotton, and gun-cotton. It can be used for this latter purpose because bleached sulphite stock is nearly pure cellulose. The chemicals employed for cooking are chiefly sulphur, and lime. The chief trees used are spruce, balsam, and hemlock. The resulting fiber is called sulphite pulp.

Soda fiber is soft but it lacks strength and length. It is a good filler, however, and gives a good printing surface. Its chief use is as a constituent in book papers. The chief tree used is poplar, as this process is better adapted to the utilization of hardwoods than are the others. The wood is digested or cooked in a caustic soda solution, and the resulting fiber is known as soda pulp.

The sulphite process is a modification of the soda process, and is used chiefly in making wrapping and other heavy papers where strength is desirable and a dark color not objectionable. The celebrated kraft paper is an example, so called because of its strength. The chief tree used is the southern pine, followed by spruce and balsam in the United States, and spruce and balsam in Canada.

The production in tons by different processes in the United States and Canada for 1919 was: [1]

Class	*United States*	*Canada*
Groundwood	1,518,829	990,902
Sulphite	1,419,829	562,115
Soda	411,693	4,597
Sulphate	120,378	158,475

Most plants have recovery systems whereby the chemicals can be collected and used again, but these are not wholly successful.

Treatment of chips. — In making sulphite stock — and the other two chemical processes are similar — the chips are first conveyed to revolving cylindrical screens in which all grit is removed and then carried to digestors by means of mechanical conveyors. A digestor is a large cylindrical steel tank lined with bricks, between which is some acid-resisting substance. In the digestor the chips are cooked in a solution of sulphuric acid for ten hours by steam at a pressure of one hundred pounds. The pulp is then drawn off to concrete pits where the acid is washed out, when it goes to storage tanks. From the storage tanks it is pumped as needed to screens which remove the coarse particles, and is then distributed in a thick layer over felt in machines which squeeze out most of the water by heavy pressure. It emerges in the form of heavy pink sheets, in which condition it can be stored or shipped.

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[1] R. S. Kellogg, *Pulp Wood and Wood Pulp in North America,* pp. 224 and 235.

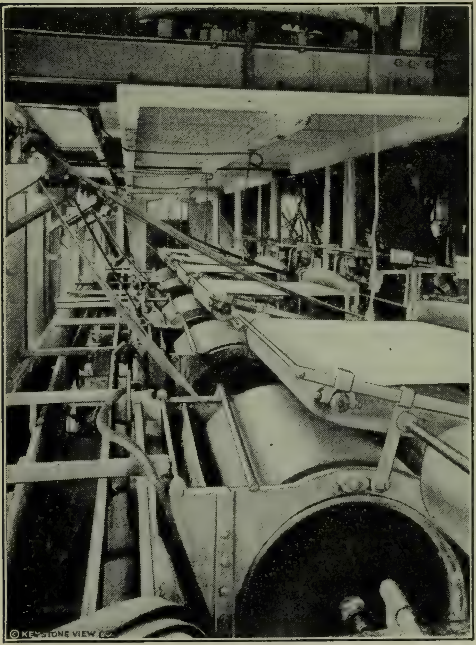
Mechanical pulp. — The majority of logs cut is made into mechanical or ground pulp. This type of pulp was first made in 1844 in Saxony. The requirements for ground pulp are a wood of light color, even texture, long fiber, and little resin. Spruce and balsam constitute 90 per cent of the wood used in this process. The impurities remain in this kind of pulp, but in chemical pulp they are removed by the chemical processes. In the grinding room there are rows of grinding stones about four feet in diameter and with a grinding face of from fifteen to thirty inches, revolving on long horizontal shafts and enclosed by heavy cast-iron casings. These cylinders extend like the spokes of a wheel from the outer circumference of each casing. The logs to be ground are placed within these cylinders, their ends being faced against the revolving stones by hydraulic rams, when the log is torn up by the action of rough stones. A flow of water is maintained on the stone to prevent friction and to carry the ground pulp away. In such a machine the main battery consists of 48 grinders with 144 logs being ground at one time, a log being ground to pulp in two minutes and forty seconds. Each cylinder grinds 225 logs in a day or 45 feet of logs each hour. Each cylinder requires 325 horsepower, and in addition to that a large amount of power is needed to operate the pumps which furnish the pressure to the hydraulic rams, and also to operate the conveyors.

Treatment of the pulp. — After being ground, the pulp is mixed with pure water and drawn into a series of wooden channels with obstructions which catch grit and unground pieces of wood. The refuse is removed by flushing at intervals. The pulp then passes over two sets of screens, the first one catching slivers and the other pieces of wood and grit, and then on to machines which reduce the fluid to a thickened mass; then it is conveyed to concrete storage tanks. At this stage the sulphite stock is mixed with the mechanical stock in beating machines, and the whole mass reduced to a smooth pulp. In this process the sheets of sulphite stock are torn up and made fluid with water which is a residue of the ground pulp, and then mixed with the ground pulp in an elliptical-shaped tank about four by ten feet in dimensions. A broad wheel with many sharp teeth or ridges revolves against the ridged surface of a dam and by means of the current formed by its revolution rasps and draws the pulp violently through between its teeth and the surface of the dam. The fluid mixture then goes to chests where the beating process is continued until it becomes fine and smooth, when it is ready to be made into paper. In the meantime it passes to other chests where it is stirred to prevent settling until it is drawn to the paper machines in a milk-like state.

Refining processes. — Next come the refining processes, which comprise the beating, dyeing, sizing, and other special treatment of the pulp necessary to produce particular grades of paper. Beating is necessary in order to reduce the fibers to uniform size, to split the ends, and to soften the edges so as to promote matting on the screen of the paper machine. If colored paper is desired, the appropriate dyestuffs are added. Loading is the adding of certain minerals, as clay, chalk, and talc, in order to fill up the spaces between the matted fibers and give body to the paper. This makes the paper compact, and gives smoothness, uniformity of surface, and opacity. Sizing is perhaps the most important process which goes on with the beating. The purpose is to give the paper the necessary resistance to ink so that it can be written upon without the ink spreading.

It will be noticed from the diagram (p. 476) that water plays a very important part. Its two main functions are washing and conveying. Not only must it be furnished in enormous quantities, but it must be clean and colorless. In the majority of plants water is filtered, and in many cases chemically treated, in order to insure its purity. As to quantity, we are told that " a mill making 130 tons of pulp and paper in 24 hours uses twenty million gallons of water in that time, which is almost as much as the amount consumed by an industrial city of 125,000 population."

Making pulp into paper. — The process of changing the pulp into paper consists in taking up an even supply of the pulp on an endless wire-gauze apron or on wire-covered cylinders which drain off the most of the water; the pulp is then passed to an endless sheet of felt, and finally it is run between successive sets of rollers which squeeze out the water and dry the paper. Where wire-covered cylinders are used, the pulp is in a vat which forms the base of the front end of the machine. Five cylinders, 14 by 3 feet in dimensions, are hung so that they are about two-thirds submerged in the fluid. These cylinders are covered with wire cloth and revolve slowly, taking upon their surface a thin layer of the pulp. As the pulp is brought to the top of the cylinder most of the water is drained away. Along the opposite side of the cylinder heavy rollers press down to the cylinder an endless sheet of felt to which the fibrous material adheres. This sheet of felt carries the pulp over a series of rollers which squeeze off the water which remains and compress it into a thin continuous sheet. After passing over steam-heated rollers this sheet is strong enough to sustain itself. Now it passes to the large drying rollers which are filled with steam around which it passes until fairly dry. From this first set of drying rollers it is taken by a set of smoothing rollers which remove the marks of the wire and the felt. It then passes through a second set of drying cylinders,



A DRYING MACHINE

The rolls of paper come from the sorting machine to the drying machine, where they are dried out.

from which it goes to the calenders or polished rollers. The calenders by great pressure give the paper a hard surface. Then the paper is wound into rolls about three feet in diameter, covered with a wrapper, and taken to the cars for shipment. If newspaper sheets are desired, the endless sheet is sometimes run through a cutting machine which cuts and piles the paper in ream lots.

The paper machine. — The paper machine just described is a triumph of engineering skill and is only less wonderful than the great newspaper printing presses which literally devour the rolls of newsprint. A man making handmade paper can produce about 200 sheets of high-grade paper or 1200 sheets of lower grade paper per day. A modern paper machine, known as the Fourdrinier, 177 feet in length, 18 feet in width, and 16 feet in height, turns out paper at the rate of 500 feet per minute of the former and double that quantity of the latter, within a few minutes after the pulp has entered the machine.

If the machine is only a pulp board machine, which is used by the plants making pulp, but not paper, the fluid is taken up in the same manner as in the complete paper machine, but it is wrapped around a cylinder metal of sufficient thickness to form a board and then cut from the cylinder. These boards are stacked and tied in bundles suitable for shipping. In this form we get all of our imported wood pulp.

The following table shows the amount of different paper products manufactured in North America in 1922: [2]

News print	2,590,000	tons
Boards	2,270,000	"
Book and writing	1,410,000	"
Wrapping	920,000	"
Other grades	1,260,000	"
Total	8,450,000	tons

Rag paper. — All paper of a high quality such as that found in stationery is made of rags. In the United States most of the high grade papers are manufactured in Holyoke, the paper city of the nation. A comparison of the old and the modern methods of manufacture is interesting. The early paper makers piled the cut rags in a moistened condition in cellars or vats to rot. In from one to three weeks after the vegetable gluten had evaporated or decayed a part of the moisture was evaporated by heat, chemicals, and power, leaving a pulpy mass. This pulp was next bleached and further disintegrated either by beating with mallets or by stampers operated by water or wind power. Now it was ready to be made into paper. The pulp was put into a vat and the workmen given a mold resembling a sieve, of the size of the intended sheet of paper. In this mould he dipped up some of the pulp and allowed the water to drain off through a slot on the bottom of the mold. The sheets thus formed were subjected to pressure, first between felt or woollen cloths, and then alone; they were then sized by being dipped into a solution of gelatine or glue. When dry the paper was pressed and made into bundles. Hot pressed paper was made glossy by pressing it between hot plates of polished metal.

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[2] R. S. Kellogg, *Pulp Wood and Wood Pulp in North America*, p. 49.

Under the modern method the rags are first put through a duster, and then conveyed over wire screens to remove foreign particles such as pins, hooks, or buttons. If these are ground up with the rags they impair the quality of the paper. The rags are then cut up by drawing them across a knife held in an upright position on a table, or by being put through a cutting machine if the pieces are small. Next they go into an iron boiler, in which there is a solution of lime and other chemicals, and are cooked with steam for several hours. After the cooking process they are washed with fresh water in a beating machine and then reduced to a pulp in this same machine. Chlorine is added for bleaching purposes and the mass is run into beating machines which reduce it to a fine, smooth pulp. After a thorough mixing with the purest spring water it is ready for the paper machine, which is similar to that used in making newsprint but smaller. The water mark is impressed by a wire roller, upon which the design is sewed, while the paper is damp. The outline of the design is left thinner than the rest of the paper and is visible when held to the light. When dry the paper is sized by passing it through animal glue. Sizing fills the pores and prevents the spreading of the ink. Blotting paper is not sized. It is then thoroughly dried in lofts where it is hung over poles or by the aid of steam heat, and the surface is smoothed as demanded by the trade. One large paper making concern in Holyoke uses enough water every twenty-four hours for power purposes to cover a 100-acre field ten feet deep; and besides this, 5,000,000 gallons of spring and filtered water are used in the manufacturing processes.

Other uses of paper. — Paper has been made into many articles which serve as a substitute for cloth, and in many cases it is more hygienic and in most instances cheaper than cloth. It is drawn out into thin sheets and made into napkins and tablecloths. In Germany during the World War, when foreign supplies of cotton and leather were cut off, paper was used for handkerchiefs, shirts, and even shoes. Paper vests are also made of pulp-sheet paper which has been chemically treated; they are light and pliable, and exclude the cold well. Some papers have been made nearly as tough as linen, but moisture destroys this toughness.

There are any number of other uses to which paper has been put aside from those common in the publishing and commercial world. Paper treated with paraffin is impermeable to water. In this form it can be used as wrappers for food and as containers for liquids. Paper milk bottles for instance are only half as heavy as glass ones, cost only half a cent each, and are much more hygienic. They will also stand a pressure of 200 pounds before collapsing. We have learned to drink out of sanitary paper drinking cups, and dry our hands on paper towels. Paper dishes of a poor quality are made now, but it is not an impossibility of the future that we should serve meals on paper dishes to be discarded after use, as drinking cups are now. What a boon this would be to the housewife! Large amounts of filtering paper used by chemists, bromide paper used in photographic work, paper pencils, and *papier maché* goods are sold annually. In electric lighting the brown substance used as a non-conductor on the inside of the light sockets is a compressed paper which has been chemically treated.

Economics of paper making. — The volume of the demand for paper, the nature and occurrence of the raw material, the nature of the manufacturing operations, and the extent to which machinery and power must be utilized, make the application of large-scale, specialized methods to the manufacture of paper easy. The required machinery is expensive and the labor requirements are small comparatively. In addition, the raw material is handled in a continuous stream. This makes possible a complex specialization of labor and machinery. Another influence tending to make the industry one of large-scale methods is the question of reforestation. The large capital investment required and the time that must elapse before the trees can be cut is not conducive to small-scale or individual enterprise.

Machinery is used extensively. As these machines are specialized and expensive, and must be operated at their full capacity to be profitable, small scale operations are nearly out of the question if there are large-scale competitors in the field.

Conclusions. — The manufacture of paper is becoming increasingly important and will always be necessary. The cost of obtaining our supply of paper is an important question at present. The necessity for extensive and costly reforestation projects to replace the ever declining supply of lumber is an important problem confronting the consumers of lumber products in general. Many products have been substituted for lumber in making paper but, except for those that enter into superior qualities of paper, none has proved satisfactory, except in the manufacture of coarse grades of wrapping paper. This causes the question of the conservation of lumber and old paper to be a matter of first importance. Old papers are salvaged to some extent, but for the most part they are wasted. Odds and ends of lumber go up in smoke every day. Thousands of worn out railroad ties are burned every year. At present it does not pay to save these products. Probably in time though, as prices go up, it will be found profitable to utilize all of these waste lumber products.

SUGGESTIVE QUESTIONS

1. To what extent, if at all, are the skins of animals used to make paper at present?
2. What vegetable fibers, in addition to those from lumber, are used now in the manufacture of paper?
3. Is a wasp's nest paper?
4. Of what fiber are our bank notes made?
5. Can you tell by tearing a piece of paper and examining the fibers, what it is made of? Try it.
6. Of what is the wrapping paper which comes around meats and groceries made?
7. Examine an old newspaper, especially if it has been exposed to the sun, and see how brittle it is.
8. Can the paper from used newspapers be used again in the manufacture of newsprint? If so, find out how it is reclaimed.
9. Ask the librarian at your Public Library how long the modern books will last; how long the newspapers.

10. Find out the methods of forestation that are practiced by some wood pulp plants.

11. List the states in the order of their importance in the manufacture of wood pulp.

12. Why does New York State make such a large amount of wood pulp?

13. List the species of trees, in the order of their importance, that are used in making wood pulp.

14. Find out the extent of paper manufacturing in Holyoke.

15. Find out the process by which rag paper is made.

16. What is the water mark on paper? How is it made?

17. The paper in some of the illustrated magazines has a very high glaze. Why?

18. American books generally weigh much more than British books of the same size. Why?

19. Do you know of any other uses for paper besides those mentioned in the text?

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CHAPTER XXXIII

CHEMICAL INDUSTRIES: IRON AND STEEL

Importance of iron. — Under chemical industries are comprehended not simply those industries which manufacture the different chemical products of commerce, but also those industries in which the raw material used goes through a chemical process which changes its nature and appearance during the process of manufacture, so that the finished product is a different article from the raw material. The iron and steel industry is the world's most important chemical industry. Iron ore, coke, and limestone are mixed in a blast furnace and heat is applied. The heat causes the materials to melt and part of the impurities to be eliminated as a result of chemical changes. Pig iron is the result of this process. Further processes purify this pig iron and give it qualities which make it available for certain uses. Other chemical industries are the manufacture of coal tar dyes, glass, sugar, rubber, and cement, the smelting of copper and various other metals, the manufacture of artificial nitrates, of gas, of petroleum products, and of perfumes.

The previous history of man has been divided into the Stone Age, the Bronze Age, and the Iron Age, each marking a higher stage in industrial development, corresponding to man's ultilization of more efficient material for making tools and appliances of various sorts. Of the invention of the smelting of iron Lewis H. Morgan has said:

"The production of iron was the event of events in human experience, beside which all other inventions and discoveries were inconsiderable, or at least subordinate. Out of it came the metallic hammer and anvil, the axe and chisel, the plow with an iron point, the iron sword; in fine, the basis of civilization which may be said to rest upon this metal."

The present age may be called a Steel Age, for upon steel is based the whole fabric of present day material civilization. A nation which possesses neither iron ore nor coal, without which the manufacture of steel is impossible, stands little chance of becoming an important world power. All of the important world powers, — England, Japan, Germany, France, and the United States — possess one or both of these resources. Italy has an industrious and dense population, but she lacks coal and has but little iron ore. The desire to control the iron ore supplies of France may be set down as one of the important causes of the World War, and the control of iron ore and coal resources is one of the questions which has caused the post-war turmoil in Europe. Modern manufacturing, agriculture, transportation, and war are impossible without steel. It is needed for building the large skyscrapers and bridges, for manufacturing factory machinery, railroad equipment, ships, agricultural machinery, and for making cannons and guns to be used in war. In addition it is employed in countless other articles of common use without which modern industry could not maintain its present pace. The steel industry ranked second among the manufactures of the United States in 1924.

Stages in the production of iron and steel products. — An idea of the order and number of operations and of the variety of products made in the production of iron and steel may be obtained from the diagram at the top of page 488.[1]

Stages in steel making. — After the iron ore has been mined and transported to the steel plant, there are three stages through which it must pass before it is in the form of a finished steel product. These stages are (1) the reduction of the iron ore to pig iron, which is done in a blast furnace; (2) the changing of the pig iron into steel, which is done by cementation, a Bessemer converter, an open hearth furnace, or an electric furnace; and (3) giving the desired shape to the steel, either by forging, founding, or rolling. Of these final processes forging and rolling are both used extensively at the present time.

The chemistry of iron. — The process of making steel begins with the making of pig iron from iron ore. This iron ore is usually an oxide of iron, that is, it is a combination of iron and oxygen, and it is contaminated by the presence of various impurities such as earthy materials. The oxygen can be separated from the iron by mixing the iron ore with charcoal or coke or carbon and heating the mixture red hot. The resulting product is a sponge

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[1] Report of the U. S. Commissioner of Corporations on the Steel Industry, Part III (1913), p. 13.

- Ore, Coke, Lime-stone → Pig Iron
  - Steel making iron, Bessemer, Basic
    - Ingots
      - Blooms
        - Large billets
          - Rods: Wire, wire nail, & wire products
          - Merchant bars
          - Angle bars
          - Splice bars
          - Hoops and bands
        - Small billets
          - Merchant bars
          - Light hoops
          - Cotton ties
          - Seamless tubes
        - Sheet and tin plate bars
          - Sheets, galvanized, and other finished
          - Black plate for tinning
            - Tin plate and tern plate
        - Rails
        - Structural shapes:
          - Beams
          - Channels, Angles, Tees: Bridge and other fabricating material
          - Zees
        - Axles
      - Slabs
        - Plates:
          - Structural
          - Boiler
        - Skelp: Wrought pipe and tubing
    - Castings
    - Forgings
  - Foundry iron castings — Castings
  - Malleable Bessemer iron — Malleable castings
  - Forge iron — Muck bar — Merchant bar iron and other rolled-iron products

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of iron containing the earthy matters or gangue and is therefore impure, and is moreover infusible. To produce pig iron this deoxidized iron must be separated from the earthy parts of the ore and coke and must be made fusible. This operation is conducted in a blast furnace where the iron is smelted by coke at a very high temperature. At the same time limestone is introduced to form a fusible slag with the earthy parts of the ore and thus separate them from the iron. This is all carried out in one operation in the blast furnace.

But the resulting pig iron is an impure iron containing carbon, silicon, sulphur, phosphorus, manganese, and sometimes very small quantities of other elements such as arsenic, titanium, copper, chromium, etc. Some of these constituents are desirable in certain proportions in steel, while others must be got rid of. The pig iron must therefore be subjected to further chemical changes to produce steel of the desired character and quality. Carbon occurs in pig iron in two forms — as graphite and as combined carbon. Graphite occurs in uncombined flakes throughout the iron, which is weakened by their presence, as it tends to break along the lines of these flakes. Combined carbon is very hard and strong so that its presence increases the hardness and strength of the metal, and a certain amount is very desirable. Silicon is always present in pig iron, upon which it has a twofold influence. Its direct effect is to harden the iron, but its indirect effect is to soften it by changing the carbon into graphite and so throwing it out of combination. To obtain hardness, elasticity, and tensile strength the proportion of silicon in iron must be kept small. The effect of sulphur is usually harmful and therefore every effort is made to avoid its presence or to get rid of it. Phosphorus is always present in pig iron, though in varying quantities, and tends to reduce the tensile strength; as it cannot be entirely eliminated the only way to manufacture iron low in phosphorus is to use an ore which contains little. It may, however, be reduced to as low a proportion as .005% by the basic hearth process. Manganese is always present in pig iron and tends to render it brittle if present in large quantity.

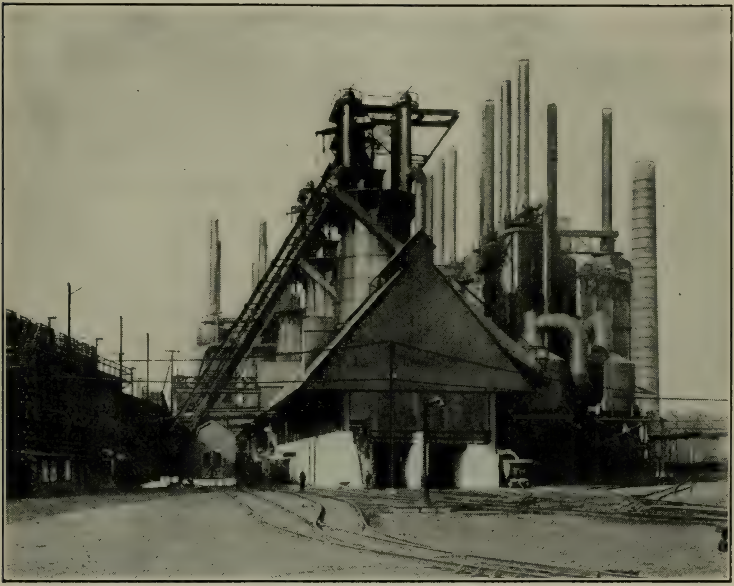
Pig Iron in a Storage Yard

The determination of the amounts of these elements present in a given mass of pig iron, the elimination of those not wanted, and the possible addition of others which are needed, are chemical processes. The manufacture of pig iron and the transformation of iron into steel may therefore properly be called a chemical industry.

Early methods of converting the ore into pig iron. — Until the Bessemer process was invented in 1855 practically no change had taken place since prehistoric times in the principle employed in smelting iron ore. The equipment was modified and improved, but the metallurgical process remained the same. Early smelting was done in a forge with charcoal as a fuel. The ore was placed in the fire and a bellows forced air against the fire, causing it to become hot enough to reduce the ore to a sticky molten mass. The resulting iron was then purified by pounding or hammering, giving a metal which is scarcely excelled to-day for excellence of quality. Pictures on the walls of Egyptian buildings, which date from 3500 B.C., show Egyptians smelting iron with the aid of a goatskin bellows.

Gradually the forges were built higher, in the form of great chimneys, and the draught was made stronger and given the name of a blast. The first blast furnace, which was much smaller than modern ones, was built in Belgium about 1340. The fuel used was charcoal and smelting had to be carried on near the forests; when these were burned down the iron industry was shifted to a new spot where charcoal was available. In addition to scarcity there was another difficulty connected with the use of charcoal as a fuel. It was impossible to pile up a mass of iron ore and charcoal very high, because the weight of the ore would crush the charcoal and smother the fire. A limit was therefore placed upon the size of blast furnaces, and they remained small until the use of coke was discovered. The method of converting coal into coke and using this to smelt iron in a blast furnace was discovered in England about 1740. Since coke is hard it was now possible to pile up the coke and ore to a considerable height and still force the blast through to feed the fire. Iron could now be produced much more cheaply, and in larger quantities, but there was a sacrifice of quality, since the iron produced in these furnaces contained many impurities, and was not so strong nor so malleable as the former product.

A modern blast furnace. — The iron ore of to-day is converted into pig iron in the blast furnace, a tall chimney-like structure consisting of a shell of steel plates riveted together like a large cylinder or upright steam boiler and lined with a firebrick wall about three feet thick, the lower portion, which must stand the greatest heat, being surrounded with hollow bronze brick filled with rapidly flowing water. A typical blast furnace is about 50 to 100 feet in height, 25 feet in diameter, being widest at the center and tapering toward both ends, the bottom being only about half as wide as the center. Such a furnace holds 1500 tons of material, and makes 550 tons of iron every 24 hours.



A MODERN BLAST FURNACE

This illustration shows the storage bins, the inclined railway leading to the charging platform at the top of the furnace, the pipe leading from the top of the furnace to the dust catcher, the stoves for heating the hot blast, and the other features described in the text.

(a) *Charging the furnace.* In charging the furnace, alternate loads of ore, coke, and limestone — the latter to remove the impurities in the iron ore — are dumped in at the top. Between the stockpile and the furnaces at one of the large Gary plants are two parallel rows of storage bins, one for coke and the other for ore and limestone. The material is delivered from these bins to electrically operated lorries which carry the material to the furnace skip or car, of which there are two to each furnace. These skips run up an inclined railway to the charging platform at the top of the furnaces and automatically discharge their loads into a hopper at the top of the furnace. These skips make one trip per minute and deliver at each load about 7000 pounds of ore, 6000 pounds of limestone and 3600 pounds of coke. Within the furnace are two cones. The material falls upon the first one, which is then lowered, allowing the material to fall upon the second. The first one is then drawn up, sealing the entrance, after which the material is discharged into the furnace by lowering the second cone. This arrangement prevents the escape of gases.

This material, after being put into the furnace, is reduced to a molten state by forcing up through it from the bottom of the furnace a hot blast of air, which is necessary for the combustion of the coke. The air is introduced at the bottom of the furnace just at the top of the hearth, through a series of 8 to 16 water-cooled tuyéres.[2] These tuyéres are cylinders of fire-clay about 18 inches in length and 4 to 7 inches in diameter, through which the hot blast is driven to burn the coke and furnish the heat for the smelting operation. The number and size of the tuyéres vary according to the diameter of the hearth, the volume and pressure of the blast, etc. A great amount of air is needed for the combustion of the coke, and this is provided by huge blowing engines located near the furnace. About four to five tons of air are required for each ton of iron produced. Since higher temperatures are obtainable in the furnace through the use of a hot blast than would be possible through the use of cold air, provision is made for preheating the air by forcing it through hot blast stoves adjacent to the furnace. Four of these are connected with each furnace.

(b) *The hot blast.* These stoves are of about the same height and bulk as the furnace itself and are filled with a honeycomb of fire-brick. A cold blast of air is forced by the blowing engines into the hot blast stoves at the bottom and as it passes upward it absorbs heat, being finally carried from the stoves through a pipe into the furnace as a hot blast. In making this hot blast, the gases generated by the burning of the material in the blast furnace itself are utilized. Formerly these gases were allowed to burn at the top of the furnace, being a total waste, but now they are conducted from the top of the furnace by a pipe to a dust catcher where they are cleaned. From here they are led to the stoves through openings a short distance above those through which the cold air enters. The saving in the fuel bill of the blast furnace by using these gases is about 30 per cent.

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[2] Pronounced twee-yair.

In heating the air, two stoves are heated at a time. As the burning gases pass through they heat the firebrick to a high temperature, and when the proper temperature is reached the gases are turned into the other pair of stoves. At the same time the cold blast is let into the heated stove and in passing up through it absorbs the heat given up by the gases, and enters the blast furnace at a high temperature. The hot blast enters the furnace at an average pressure of about 15 to 30 pounds per square inch. The products of the burning gases pass out through smokestacks provided with valves, at the top of the stove. The gas and cold air inlets, the smokestacks and hot air outlets are all provided with valves which are so manipulated as to prevent the loss of any of the air or gas. Part of this gas, after being cleaned and washed, is taken back to operate the blowing engines and the gas engines in the electric power station.

(c) *Smelting the ore.* About three weeks are required to bring a new blast furnace up to its full working charge and temperature, but after it is once started it is kept going continuously until the lining must be renewed. Some furnaces have a record of several years' continuous operation. In a furnace the temperature varies from about 3500° F. in the hearth where the molten iron collects, to that of the cold charge of material as it is fed in at the top. As the load sinks from the comparatively cool top to 400° F. of heat the chemical action of the blast of air removes 90 per cent of the oxygen in the ore and transforms the ore into a finely divided sponge of malleable iron, which encloses the earthy gangue and is moreover infusible. At 430° F. the ore begins to take on carbon from the coke amounting to several times its own volume, whereby the metal becomes more fusible; opposing chemical action sweeps it away; again it returns. This chemical battle continues until the load sinks to 900° F. of heat when the carbon ceases to increase. From the 900° F. point down to the process of fusion the iron sponge continues. As it descends it melts and separates into iron and slag. The fusible compound of iron with carbon and other impurities constituting pig iron trickles through the incandescent coke at a temperature of 3500° F. to the bottom of the hearth below. Above the pig iron floats the lighter slag, which is a combination of the lime from the limestone fused with the earthy matters of the ore and the ashes of the coke.

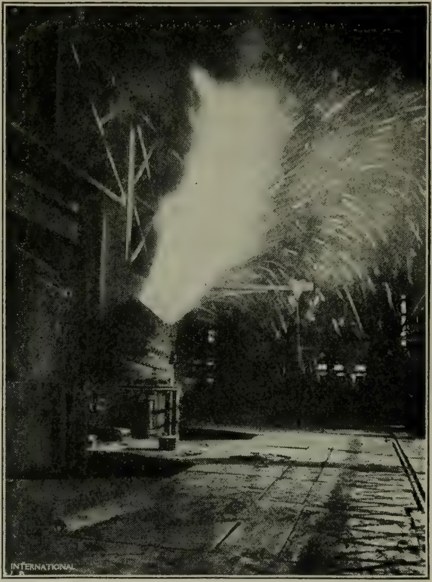
The slag is drawn off at frequent intervals through a special opening and hauled away to be crushed and made into cement in cement mills. Through another opening, which is kept closed by a piece of clay, the molten iron is drawn out into large ladles in which it is taken to the mixers by locomotives. A mixer is a large horizontal cylinder lined with firebrick and holding about 1300 tons, its function being to act as a storage reservoir from which the hot metal can be drawn as required by the converters.

If the metal is to be converted into steel immediately it is emptied from the mixer into ladles and taken to the Bessemer converters or open hearth furnaces. If, however, it is to be made into steel later or at a different plant the molten iron is allowed to run into a ditch or " sow " with many lateral ditches or " pigs " branching from it, there to harden, the hardened bars being called pig iron. A drawing of molten iron is made about every four hours and 100 tons are taken at every draw, requiring 15 minutes to run out. While the notch is being replugged the blast is stopped, during which interval the load in the furnace sinks slightly. As tapped from the furnace the pig iron contains from 3 to 4 per cent of carbon, which is subsequently removed in the steel making processes.

Making pig iron into steel. — As it comes from the blast furnace, the cooled cast iron, or " pig " as it is called, does not possess sufficient bending and tensile strength. It lacks the ductility, toughness, elasticity, and all around strength which is required of most commercial iron products. This condition is due to the excessive amount of carbon, silicon, phosphorus, sulphur, and manganese which are still present in the metal. These impurities must now be burned out either by the cementation process, in the Bessemer converter, in the open hearth furnace, or in the electric furnace. As the first of these is relatively unimportant the further description will be confined to the three last.

(a) *Bessemer process.* The old cementation process did not produce steel in sufficient quantity or at a price low enough to meet the demands of modern industry. But in 1855 Henry Bessemer developed the so-called Bessemer converter, an epoch-making invention which completely revolutionized the steel industry. A Bessemer converter is a barrel shaped vessel, varying from 10 to 16 feet in inside diameter and from 10 to 20 feet in height, lined with from 1 to 1½ feet of refractory material to protect the steel shell from the heat, and supported at the middle on trunnions which permit of its being tipped to be loaded or unloaded. An air pipe is led in through one of the trunnions and continues to the air chamber at the base of the converter, from which the air enters the converter through from 150 to 200 perforations.

The pig iron is treated by loading from 10 to 25 tons of molten iron into a converter and then turning on a cold air blast, which is forced up through the liquid mass at a pressure of about 20 to 25 pounds to the square inch. The oxygen of the air combines with the carbon and other impurities of the iron and sets up a violent combustion, soon raising the temperature to about 3000° F., with the result that in 10 or 15 minutes all of the impurities and most of the carbon have been burned out, only pure iron remaining.



Bessemer Converter in Action

The color and density of the flame issuing from the mouth of the converter show the operator what is going on inside and from this he can tell when the process is finished. As the silicon begins to burn there is an orange-yellow flame, edged with blue. Then, as the carbon starts burning, the flame changes to a bright flickering one which rushes violently forth, accompanied by streams of sparks. Finally the flame dies down and the process is completed. But the product is not yet steel. It is merely an unadulterated iron without special characteristics. It is now changed into steel by mixing with it with great exactness a certain amount of the elements which have been burned out, and frequently other desired elements, the amounts and proportions of each ingredient varying according to the kind of steel desired. This is done by tipping the converter and putting in a high carbon iron called "spiegeleisen" before the contents are poured out. Then the contents are poured into a ladle from which they run through a nozzle in the base of the ladle into cast-iron ingot molds, which are placed three on a truck, in trains, and are 6 feet tall and about 2 feet square.

A group of workers is kept busy doing repair work around the converters, since the heat burns them out quickly. The converter must be relined once a week and the ladles oftener. The converter bottoms, where the heat is greatest, must be rebuilt every other day. The stopper in the ladles, a steel rod covered with fire-clay, must also be rebuilt frequently, as must the tuyéres, the cylindrical openings through which the air blast enters. If these burn down too short, they might break through and allow the iron to get into the air chamber. If only one or a few are faulty, it is stopped up with clay and a plate fastened over it. A bottom may be kept in service in this manner longer than if no attempt were made to check the destructive action of the metal.

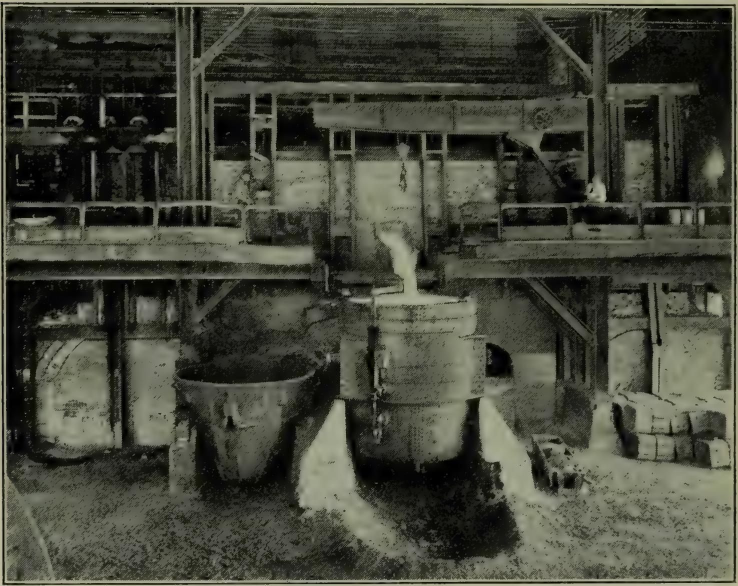
(b) *The open hearth process.* Although the Bessemer process makes steel in large quantities, cheaply and quickly, it does not produce a product which will stand great stress such as is required in steel rails and bridge building material. Bessemer steel often breaks without warning. To remedy this the open hearth furnace was developed.

An open hearth furnace is a rectangular structure about 15 feet by 40 feet in dimensions, with a roof of silica bricks 15 inches in thickness and a floor built of several layers of clay brick, covered over with a lining of magnesite slightly curved upward toward the edges so as to form a basin. At each end are two large openings, one for air and the other for gas. An open hearth furnace must be regenerative in order to get the necessary intense temperature. By a regenerative furnace is meant one in which the heat carried away in the stacks is used to warm the air and gas before these enter the furnace. The capacity of these furnaces varies from 5 to 125 tons, but the average is from 60 to 75 tons; and from 8 to 12 hours are required to complete one charge of materials.

The method consists in exposing molten pig iron, steel scrap, and limestone to the heat of a gas flame and to the action of heated air as they enter through ports or openings at either end of the containing furnace. Melting is accomplished by burning fuel in the end of the furnace in conjunction with highly heated air that has come in through a series of checkered brick chambers which are located at either end of the hearth. These chambers are connected with the flues and as the gas is admitted from one end through the checkerwork the flame sweeps across, and the resulting heated gas and air pass through the checkerwork at the other end, heating the contents to a high temperature. At intervals of 20 to 30 minutes the flame is reversed by admitting the gas from the opposite end. This drives the air through the opposite checkered brick chamber and as it goes through it absorbs the heat in the bricks, thus yielding a high temperature on uniting with the fuel. The continued reversal of the flame permits the maintenance of a high even temperature, which is the basis of the open hearth process. "The problem in an open hearth melting furnace is not to *reach* the desired temperature, but to *control* the temperature and prevent the roof and walls from melting down." The fuel first employed in the open hearth furnace was natural gas, but now producer gas, by-product gas, and fuel oil are used extensively.

In charging a furnace, the materials are assembled in boxes from bins in the stock yard and pulled to the open hearth building by a small engine. Here a machine, with a revolving arm locking into the end of the charging box and moving in any direction, takes a box and thrusts it into the furnace after the door has been opened. When it is in the furnace, the arm is revolved thus causing the material in the box to drop on the hearth, and then the box is withdrawn. A charge consists first of a layer of limestone, then one of ore, and finally one of scrap iron which makes up about 40 per cent of the total metallic charge. This mass is heated until the scrap is white-hot and slightly fused, then molten pig iron taken from a mixer is added, being poured from a ladle into the furnace. With this addition the impurities are burned out and form a slag, part of which is drawn off at the end of two or three hours. This purifying process is kept up for 8 to 12 hours.

When the process is completed a steel bar is thrust through a hole in one of the doors, knocking out the retaining plug at the rear of the furnace, and the molten metal flows out into a ladle which has been lowered into a pit about eight feet in depth. At this time the steel is purified by the addition of deoxidizers, such as ferro-silicon or manganese, and the necessary carbon is added in the form of finely granulated coal or molten spiegeleisen. The ladles, which often hold 100 tons, are then carried by an electric crane to the pouring platform where the metal is poured into ingot molds. Sometimes the slag runs over the edge of the ladle into the pit where it is permitted to cool around steel hooks, in order that it may be more easily handled. After it has solidified around these hooks it is removed by a crane. Sometimes it is drained off into smaller ladles.



Tapping an Open Hearth Furnace

The molten metal is here seen flowing into a ladle. As the ladle fills the lighter slag is drained off the top into the receptacle at the left.

Although the open hearth method is more expensive than the Bessemer, it has so many advantages that about 75 per cent of the steel manufactured to-day is made by that method. The product is stronger and more uniform. One advantage of the method is the better control of temperature and composition. Instead of burning out all the impurities and then adding certain amounts as in the Bessemer process, the charge can be watched and the process stopped when the carbon content has been reduced to the proper amount. Samples can be taken at intervals and tested in the laboratory. This is not possible with the Bessemer converter. The temperature of the materials is also independent of the purifying reactions, thus allowing purification to take place at a more gradual rate. For these same reasons a much wider variety of raw materials can be used and a greater range of products made. Any variety of raw iron can be utilized in the open hearth process, while the Bessemer method requires a special grade with just the right proportion of phosphorus necessary to maintain the temperature required for the chemical reactions. Open hearth steel is generally lower in both sulphur and phosphorus, elements which are especially injurious in steel; the former makes it difficult to form the steel, and the latter makes the steel brittle under shock. The open hearth process is also more economical in certain respects than the Bessemer method. There is an increased output of steel from a given amount of iron and fewer blast furnaces are needed to produce the same tonnage. It is possible to use pig iron in smaller proportions of the total charge and to make use of larger amounts of scrap iron.

(c) *The electric furnace.* By the use of the electric arc as the the source of heat better results are obtained than by the open hearth process. In some establishments, when a good quality of alloy steel is desired, the metal from a Bessemer converter or an open hearth furnace is further treated in an electric furnace, the advantages of which are very high temperatures, the perfect control of temperature, and a neutral atmosphere. The possibility of making sample tests while the process is going on is also an advantage.

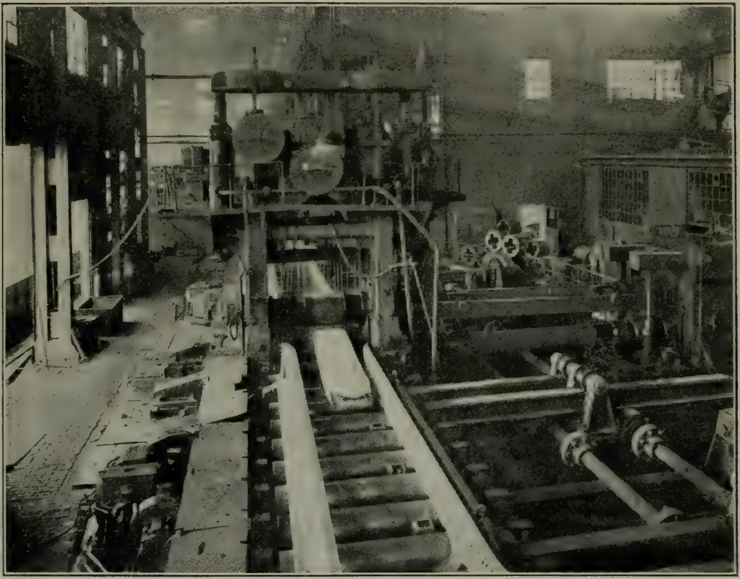
An average-sized electric furnace is about 16 feet in diameter and is made of a plate steel shell one inch in thickness, lined with three different materials: first 4½ inches of firebrick; then a lining of magnesite brick about one foot in thickness; and lastly about one foot of dead, burned magnesite. The dome-shaped roof is of silica brick, one foot in thickness. Such a furnace has a capacity of about 25 tons.

In the roof are three equally spaced openings, through which enter the electrodes, 20 inches in diameter and formed of amorphous carbon. The electrodes are carried by horizontal arms projecting over the furnace from heavy, vertically moving rods. Copper cables and copper bars carry the current from the transformer to the holders that grip the electrodes. The bottoms of the electrodes are about three-fourths of an inch from the surface of the slag, and the temperature reached is about 3000° F.

When Bessemer or open hearth steel is further worked in the electric furnace, the process lasts about four and one-half hours. First the molten metal is put into the furnace and the electric current turned on. Then 1400 pounds of lime and (if Bessemer metal is used) 900 pounds of iron oxide are added. This forms a slag for the removal of the phosphorus. When the phosphorus has been got rid of this slag is removed, and a reducing slag is made by putting in 1100 pounds of burnt lime, 200 pounds of sand, 200 pounds of fluorspar, and 200 pounds of coke dust, the purpose being to deoxidize the metal and eliminate the sulphur. Finally, after the metal has been thoroughly refined, there is added the proper amount of alloys or elements to make the alloy steel required.

Producing steel shapes: (a) *Making steel ingots.* — By whatever process steel is made it always is poured into ingot molds — hollow slablike structures — which stand waiting on small trucks on a narrow-gauge railroad track. These ingots vary in size according to the product which is to be made from the steel, but they are on the average about 6 feet in height and 20 inches square, and weigh about 3½ tons. They also are wedge-shaped and taper slightly toward the top, which facilitates the removal of the mold after the metal has solidified. When the steel in these molds has cooled sufficiently to stand upright, an engine draws the carload of molds under a stripper. This is a powerful machine which reaches down a pair of great iron chains, which lay hold of the sides of the mold and strip them off, leaving the columns of red-hot steel.

(b) *Soaking.* The steel ingots in cooling do not cool uniformly throughout. When the molds are stripped off the outer crust is hard and the interior still molten, so that if they were put under the rollers in a rolling mill they would break to pieces or collapse. To remedy this they are pulled to a soaking pit where one by one an electric crane lifts and lowers them into a flame of burning gas in which they are soaked until the mass is of uniform temperature throughout. The gas flame keeps the surface at the proper temperature while the inside is cooling. The heat is thus equalized.



Blooming Mill in Operation

The illustration shows the red-hot ingot of steel being guided to a set of rolls. Rolling consists in working metal ingots into rails, bars, plates, rods, and other structural shapes by passing them repeatedly when intensely hot between cylindrical rolls.

(c) *The blooming mill.* After the ingots of steel have been soaked they are loaded on a dump cart which deposits them on a roll table in the blooming mill. The rolling process, by which the red-hot, soft slabs of steel are made into various forms such as steel rails, armor plate, and steel billets, is the final process in the manufacture of steel proper.

A roll table is a succession of steel rollers arranged in such a manner that they revolve and carry the ingot forward or backward at the will of the person operating the controlling lever. The roll tables extend on both sides of the blooming mill, which is arranged on the plan of a clothes wringer. First two bars of steel are placed the right distance apart. The roll table is set in motion and the bar goes between the rollers with a bang and a shower of sparks. The gears are reversed, the rollers brought a little closer together by the movement of a lever and the slightly flattened bar comes back through on a second trip. At times, iron fingers reach through between the rolls and slightly turn the bar so that it may receive pressure on all sides. This process is continued until the ingot has become an elongated bar many feet in length and reduced in thickness according to the shape that it is finally to have. By this time the steel is too cold for further rolling, and it is cut into six-foot lengths which are taken to a reheating furnace to be brought to a temperature proper for the final working.

(d) *The finishing mill.* Next the short bars go to the finishing mill which works them over into marketable shapes. There are different kinds of finishing mills according to the article made, as rail or structural mills. In these mills the rolling processes are similar to those of the blooming mill, but the rollers are so shaped and spaced that they give the desired shape as the steel passes between them. The final step in all cases is the straightening, cutting and piling of the stock ready for shipment.

Alloy steel. — Certain metals can be mixed with steel to advantage. The addition of these will increase the toughness, tenacity, and durability while at the same time often conserving raw materials and reducing the weight. Manganese steel, which contains 13 per cent manganese and 1.3 per cent carbon, is tough, hard, and resistant. Steel with an addition of 3 per cent nickel is very hard. It is used in making armor plate and frames and axles for vehicles. Steel composed of 45 per cent nickel makes a cheap substitute for platinum where wires are to be led through or mounted in glass. Chromium and tungsten steel are noted for holding their cutting qualities and are employed in making lathes. Steel containing about 6 per cent of tungsten is employed in making permanent magnets. A mixture of chromium and nickel gives the high tensile strength desirable in gear wheels.

Vanadium steel has high resistance to fatigue and less tendency to break in such things as automobile parts, where the continual jolting motion causes crystallization and fracture without warning.

Future needs of the steel industry. — The two most pressing requirements in modern industry in connection with steel are for rust-resisting and heat-resisting steels. Corrosion is the greatest enemy of iron and steel. It has been estimated that one-quarter of the iron and steel which man smelts and fashions into useful products is every year destroyed by rust, a loss equal to one billion dollars annually. Since it takes four pounds of coal to produce one pound of steel, as well as considerable labor and capital, this constant destruction by rust becomes a very serious matter. The usual method of preventing rust is to paint the object or otherwise to protect it against oxidation. But a better method would be to produce a corrosion-resisting steel. A number of such steels are known to-day, such as chromium steel, but they are still too expensive for extended commercial use. As soon as they can be produced cheaply enough, they will be universally used. A safety razor blade, made from such steel, would probably retain its sharp cutting edge for six months instead of six days.

Modern processes of manufacture, of metallurgy, of chemistry, and of other arts are using increasingly higher temperatures. There is need therefore of metals to act as containers and in other ways, which will stand these higher temperatures without losing their own form or properties. Much has already been done along this line, but the great improvements still lie in the future.

Developments along these lines, as well as other improvements in the processes of manufacturing iron and steel, wait upon further work by the chemist.

Conclusions as to the iron and steel industry. — No industry in the United States has shown greater wealth of resources or more extreme concentration in large establishments, and few have experienced greater rapidity of development than the iron and steel industry. Its size and strength are based upon the exploitation of unrivalled natural resources, which it transforms into standard products on a huge scale for sale in a large and expanding market. All these circumstances have impressed upon the industry certain distinctive characteristics. One of these is mass production of heavy products with the aid of machinery and labor-saving devices probably unequalled in any other industry. Great economies are possible by these methods and the products are correspondingly cheapened, but there has been engendered a certain recklessness in production and a disregard for human values. Long hours have characterized the industry and accidents have been distressingly frequent. The large use of expensive machinery and enormous plants has involved the use of capital in great amounts — the cost of a rolling mill is said to be about $20,000,000 — and this has led to the concentration of the industry not only in big establishments but under centralized control. The iron and steel industry has had and still has spectacular features which have led foreign observers to regard it as a typical American industry, both on its good and its bad sides.

SUGGESTIVE QUESTIONS

1. Which is more important, gold or iron?
2. List some of the articles, into the composition of which iron has entered, which you have used to-day.
3. Get specimens of iron ore and of unmanufactured iron and bring them to class.
4. Identify the different parts of the blast furnace in the illustration given in the book, and tell what goes on in each.
5. Is most of the iron from the blast furnaces permitted to harden into pig iron, or is it carried to the next stage of conversion into steel while still in the molten state? Why?
6. Is the open hearth furnace really open?
7. Name some steel products which are given their shape by the process of rolling.
8. Can you mention any articles of common use made of alloy steel?
9. If a chromium steel safety razor blade were produced, what effect would it have on the sales of razor blades? Is that a possible reason why it is not produced?
10. Describe the conditions of work for the laborer in the iron and steel industry.
11. Many of the laborers in the iron and steel industry have been recent immigrants. Why?

BIBLIOGRAPHICAL NOTE

The literature on iron and steel is voluminous, and, because of constant improvements in the industry, is being steadily increased. Descriptions of the most recent practices must be sought in the technical journals.

The best American book on the production of pig iron is Robert Forsythe, *The Blast Furnace and the Manufacture of Pig Iron* (New York, 1908). The recognized standard authority on the manufacture of steel, especially the metallurgy of the Bessemer and crucible steel processes, is still H. M. Howe, *The Metallurgy of Steel* (New York, 1890). The most complete and thorough book since Howe is probably F. W. Harbord, *The Metallurgy of Steel* (London, 1905), and the best American reference book, though not for beginners, is H. H. Campbell, *The Manufacture and Properties of Iron and Steel* (4th ed., New York, 1907). Other authoritative books are O. F. Hudson and G. D. Bengough, *Iron and Steel* (New York, 1913); W. H. Greenwood and A. H. Sixton, *Iron: Its Sources, Properties and Manufacture* (Philadelphia, 1907); Bradley Stoughton, *The Metallurgy of Iron and Steel* (2nd ed., New York, 1913). More popular and less systematic is A. O. Backert (Ed.), *The ABC of Iron and Steel* (4th ed., Cleveland, O., 1921). A concise and clear description of the acid and basic open hearth processes may be found in H. M. Carr, *Open Hearth Steel Castings* (New York, 1907). An authentic, but largely non-technical discussion of the iron and steel industry is *The Story of Steel* in the Scientific American throughout the year 1924 and for part of 1925. This is descriptive and well adapted to student uses. A similar book is L. W. Spring, *Non-Technical Chats on Iron and Steel* (New York, 1917). Interesting chapters are found in W. A. Tilden, *Chemical Discovery and Inventions in the Twentieth Century* (London, 1916) and H. E. Howe (Ed.), *Chemistry in Industry* (New York, 1924).

An interesting discussion of the life of an iron and steel worker is J. J. Davis, *The Iron Puddler* (Indianapolis, 1922). A good popular book on the development of the steel industry in the United States with emphasis on the important men is H. N. Casson, *The Romance of Steel* (New York, 1907).

CHAPTER XXXIV

COAL TAR PRODUCTS

Need of science in industry. — The manufacture of coal tar products is selected for description, not because of the large value or great volume of its products or the large capital invested in it, but because it illustrates a phase of manufacturing which, until recently, has not been characteristic of American methods. This is the intelligent application of careful scientific research rather than the wasteful utilization of abundant natural resources. In no field probably has this been carried further than in the discovery and utilization of the wonderful properties contained in coal and especially in coal tar. It is not surprising to find that, before the World War, most of the work in this field had been done in Germany, for that country is poor in many of the raw materials of industry, but on the other hand has an industrious and intelligent population and an excellent system of education. In no country, in 1914, were so many chemists employed by industrial establishments as in Germany, and nowhere else, before the World War, was so much spent on industrial research. To-day the United States and England are enlisting the coöperation of science with industry and have already made great strides in those lines in which Germany had almost a complete monopoly, such as the manufacture of drugs and dyes and other coal tar products.

The chemist is the scientist who discovers new properties in matter, who invents new methods for producing by chemical processes products previously created only by nature, or who creates entirely new products by a different combination of elements. These results are not achieved by accident, but are the product of patient scientific research and of highly specialized skill. The time has been reached in the United States when further development of manufactures depends less upon the utilization of cheap raw material or upon the economies of large scale operation than it does upon the application of science to industry. The varied industries built upon the basis of coal tar furnish ample evidence of the contribution already made by chemistry to manufactures, and give hope of future triumphs along other lines.

The destructive distillation of coal. — When coal is burned in contact with air, as in a furnace or stove, water vapor, carbon dioxide, and ash are formed. Perhaps you have choked on a whiff of carbon dioxide sometime when you were cleaning out the ashes from the furnace or the stove, and have thus made the acquaintance of two of these products.

If the coal is heated equally hot, but out of contact with the air, so that it cannot burn up, certain other products are formed wholly unlike those resulting from ordinary combustion. A simple experiment will illustrate this. If you will place a piece of soft coal in a test tube (or in an ordinary clay tobacco pipe, covering the open bowl over with clay) and heat it, a gas will come out of the open end which will burn with a yellow smoky flame. After all the gas has been burned there will remain at the bottom of the test tube (or clay pipe) a dry, porous substance; this is coke, which is composed of fixed carbon, volatile matter, and ash. The process just described is known as the destructive distillation of coal, and is generally carried on for the production of illuminating gas and coke.

Now if you will look again at your test tube (or break open your clay pipe stem) you will see along in the middle some dirty drops of water and some black sticky stuff. These are ammoniacal liquor and coal tar, which were once regarded, by the gas makers and coke makers, as nuisances to be got rid of in the easiest way possible. They are by-products of the coke industry. Formerly all the coke in this country was made in so-called bee-hive coke ovens, which let all the gas escape, and threw away the ammonia and tar or sold the latter for roofing at a cent or two a gallon. To-day, however, about sixty per cent of the coke is made in by-product ovens which recover these other three products. As this chapter is concerned only with coal tar products, we shall confine our attention to tar, although it is the least in bulk. Of a certain quantity of coal, 72 per cent will go into coke, 12 per cent into gas, and 6 per cent into tar, the other 10 per cent being water. In a general way the destructive distillation of a ton of soft coal will yield the following products: [1]

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[1] E. E. Slosson: *Creative Chemistry,* p. 64.

1 ton of coal may give
- Gas, 12,000 cubic feet
- Liquor (Washings) Ammonium sulphate (7–25 pounds)
- Tar (120 pounds)
- Coke (1200–1500 pounds)

Coking. — If this were a technical treatise, it would be necessary to distinguish between the different types of coal,[2] for these differ considerably in their chemical structure and characteristics. Coal is a conglomerate of many different substances, which may be present in varying proportions in the different kinds of coal. The generalizations in this chapter are based upon the behavior of average coking coal.

Coking has two main purposes, namely to produce gas and to convert the coal into a form better adapted for use in blast furnaces and industrial plants. From either of these processes coal tar may be obtained, and is to-day actually recovered in the majority of modern plants. The coal tar may be regarded as a by-product, but, as in the case of the by-products of the meat packing and slaughtering industry, it has been found so valuable that it has completely revolutionized methods of manufacture so as to permit its recovery and utilization. Coal tar has in turn become the basis of several new industries such as dyes, explosives, pharmaceutical products, perfumes, and others.

Since our interest is in the coal tar it will not be possible to take the space to describe the interesting and important process of coking, which is worthy of a separate chapter. In modern coking plants, provision is generally made for the withdrawal of gas and by-products, during the process of coking, to recovery apparatus where these are further separated and made available for further use.

The diagram on page 509 shows the way in which the by-products are recovered and separated after leaving the coking ovens.

The recovery of coal tar. — The gas from the ovens goes through up-take pipes into the collecting main, which runs over the tops of the ovens. From the collecting main the gas is carried by suction mains to the by-product recovery apparatus, which is usually situated at some distance from the ovens. Here it enters the sump or tar seal tank, which collects the tar which has condensed along the way by cooling. The gas next enters the coolers, where a further separation takes place, the temperature of the gas, which was from 130° to 150° C. when it entered the suction mains, is here reduced to 28°-30° C. This condenses the tar and ammonia liquor, which pass to the circulating tank, while the lighter gas is carried to the exhauster. From the exhausters the gas is forced, under pressure, through tar extractors, which condenses and removes the remaining tar. The tar and ammonia liquor, collected from various sources, are all brought together in the circulating tank from which they are pumped into the decanter or tar separation tank. This tank is provided with one or more vertical partitions, and filled in such a manner that the tar and ammonia liquor separate by gravity; the tar being heavier sinks to the bottom. From the decanter the tar is drawn to the tar storage tank, and is now ready for distillation.

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[2] See Chapter XV.

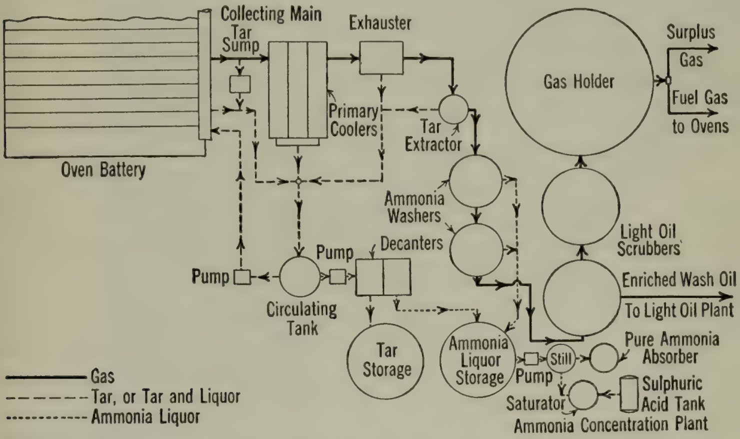

Diagram Showing the Way in Which By-Products are Recovered and Separated After They Leave the Coking Ovens [1]

Coal tar. — Coal tar obtained by high temperature carbonization is a heavy, black, oily, viscous fluid with a peculiar odor, and a little heavier than water. At low temperatures its constituents become semi-solid. The black color is due to finely divided free carbon which constitutes from 7 to 33 per cent of the total contents of the tar.

Coal tar must be distilled to be of greatest value, but the crude product is used for a number of purposes; its fuel value is equal to that of an equal amount of the best coal. It is also employed to some extent in painting wood, metal, and stone work against the action of the weather and certain corrosive chemicals. In its crude state it is used especially for painting acid pipes and condensing vessels; in making tar paper; as a cement in making certain furnace linings; as a fuel; and in the manufacture of lamp black. Lamp black, which is used in the manufacture of electric carbons, printing ink, shoe blacking, and patent leather, is made by burning the tar in ovens connected with brick chambers in which the soot is deposited before the gases escape through the chimney.

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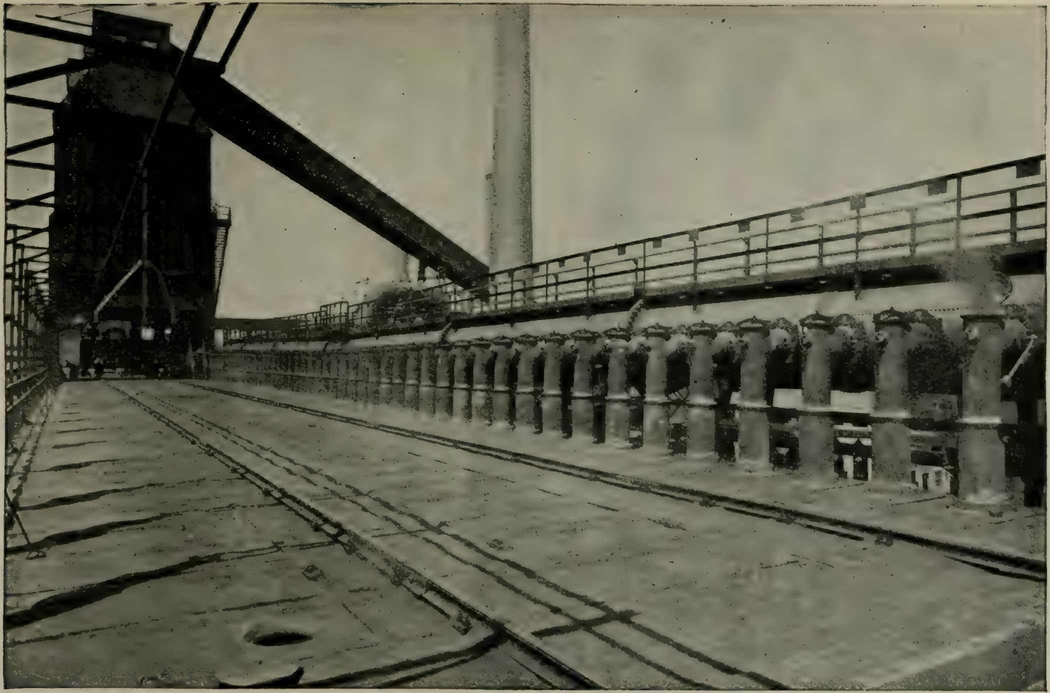
[1] From H. G. Porter, *Coal Carbonization,* p. 282.

The distillation of coal tar. — Since coal tar is a complex mixture of over two hundred compounds, each with a different boiling point, the fractional or destructive method of distillation must be employed, in order to effect the separation of these compounds. Distillation takes place in the tar still, which is an iron vessel set in brick work. At its base is an outlet for running out the pitch when the process is complete, and at the top is a pipe for conveying away the gases to the condensing coil which is surrounded by water. From the condensing coil the condensed products are taken to the receiver, a receptacle for receiving the different products as they are condensed, and which is changed for each fraction. Or the condensing coil may empty into a receptacle with several outlet pipes, each leading to a different vessel, so that each fraction as it condenses can be kept separate from the others. In the top of the still are a safety valve, a thermometer tube, and steam pipes, the latter being for the purpose of allowing steam to be blown in to prevent the pitch from hardening and caking in the still.

The still is heated from below by a furnace, the gases being led through flues surrounding the still before finally reaching the smoke shaft. The capacity of an average still is about 5000 gallons of tar, which is run into the still from settling tanks while the still is yet warm from the previous distillation.

The constituents of coal tar. — If the tar is passed through a continuous series of stills heated to different temperatures, in a continuous process of distillation, it is noticed that at different temperatures different fractions of the tar are distilled out. Thus at a low temperature (0–170°C.) light oils are obtained; by heating to a higher temperature (170–230°C.) middle or carbolic oils are obtained; at still higher temperatures (230–270°C.) heavy or



Top of Oven Battery, Showing Up-Take Pipes and Collecting Main

The collecting main, transversely placed over the ovens, receives the "foul gas" through up-takes, one from each oven entering its side or top. As the gas cools, tar and pitch are immediately formed in the collecting main, from which they are flushed out or otherwise removed.

creosote oils are obtained; and at the highest (270–350°C.) anthracene oils are obtained. At 350°C. pitch appears, and if the temperature is raised to 1200°C. all volatile materials are distilled out and only the coke residue remains.

Of the four fractions obtained, only creosote oils can be used without further treatment. They are employed in creosoting wood and for other similar purposes. The other three fractions are always, and creosote oils are usually, subjected to further treatment, which effects a more complete purification and separation into the different constituents. Without describing the technical chemical processes employed it is possible to enumerate briefly some of the more important products obtained from each of the coal tar oils. A very large variety of useful products is obtained from coal tar, because in it is contained the quintessence of plant life, the remains of centuries of forests and other vegetation.

Light oils. — The light oils are obtained largely during the process of coking, as will be noticed by a reference to the chart on page 509, rather than by the distillation of coal tar. The latter process really begins with the separation of the carbolic oils. The light oils are in turn fractionally distilled and are separated into crude benzol and naphtha. The crude benzol is further distilled into benzene (not to be confused with benzine, a kind of gasoline), toluene, and xylene, which are used in making dyes, drugs, and explosives. Naphtha is used in the manufacture of rubber goods, for burning in lamps, and for making varnish.

Carbolic oils. — Carbolic acid and cresols form the basis in the preparation of many antiseptics and disinfectants. The liquid, lysol, is a mixture of about 50 per cent cresols and 20 per cent potash of soap to which are added linseed oil and glycerin. Phenol, better known as carbolic acid, and cresols are incorporated in hard soaps and various other solid materials which are sold as disinfectants. They are also used as flotation oils to separate minerals from the earthy material or gangue.

Naphthalene is employed in the chemical industry; in the manufacture of azo-colors and synthetic indigo; as a disinfectant and as a preservative in the form of mothballs against the attack of moths and other insects; and in preserving hides.

Creosote oils. — In the United States to-day these are the most important products from coal tar. The ancients knew of the value of tar and pitch in preserving wood against the attack of weather, insects, and diseases, but the use of coal tar for this purpose dates from the discovery of the timber pickling process by John Bethell in 1838.

The Greek meaning for the word creosote is " meat preserver." Creosote can be derived from wood tar as well as from coal tar and the former variety was used by the ancients as a preservative and as a medicine for bronchial diseases. It is still used a great deal for the latter purpose. The distinction between the two kinds of creosote is that the one derived from wood tar is called *creosote,* while that from coal tar is known as *creosote oil.* The chief source of wood tar for creosote is beechwood.

After the timber pickling process was discovered, the manufacture of creosote oils progressed rapidly because of the rapid growth of railway, telegraph, and telephone systems. These oils have no equal as a preservative for wood that is to be covered with earth or water. It also protects against the organisms of the ocean which destroy wood.

Wood to be pickled is placed in a cylindrical boiler from which the air is pumped out after the wood has been put in. This exhaustion of the air in the boiler withdraws the air and a certain amount of moisture from the wood, leaving it in a better condition to absorb the creosote. Creosote oil, heated to the boiling point, is then conducted into the boiler and is forced into the cells of the wood by means of the entry of air and of a force pump; the pressure inside the boiler is about ten times that of ordinary air pressure. A cubic foot of timber normally absorbs about a gallon of creosote oil.

The life of telegraph and telephone poles, railroad ties, wooden wharves and of other wood which is to be buried in the ground or submerged in water can be trebled or quadrupled by dipping them in creosote oil. With the increasing cost of lumber and the exhaustion of forests, the use of creosote oil in this manner will be of ever-increasing importance. It is one important way in which lumber may be conserved. The black, oily appearance of railroad ties and of the bottom of telephone poles is due to their having been dipped in creosote oil.

Creosote oils are also mixed with soap and water and used as general disinfectants and as dips for animals. They are also used for treating certain diseases of cattle and sheep.

Anthracene oils. — Crude anthracene crystallizes out of its oils in about a week. The crystals are then separated from the oils by a filter process followed by centrifugals or hot hydraulic presses. It is then concentrated by washing with solvent naphtha. The liquid oils are redistilled to obtain the anthracene remaining in them. The last oils left after this distillation go back to the creosote oils. Anthracene is practically all utilized as a starter in the manufacture of artificial alizarin, an important dye material.

Of these refined products a ton of coal tar yields: [3]

25 pounds	of benzene and toluene
11 pounds	of phenol
50 pounds	of cresols
180 pounds	of naphthalene
200 pounds	of creosote
6 pounds	of anthracene

Pitch. — As a residue pitch is another important product of coal tar and results from its distillation. The various grades of pitch are valuable as road building material, for felting between the joints of paving stones, and in the manufacture of roofing felt, asphalt, briquettes, varnishes, electrical insulation, and tarmac. It is also utilized in making molds for casting steel and other metals, as waterproofing for dams and concrete work, and as a substitute for cheap grades of lubricant. The chief employment is as a binder in the manufacture of briquettes. In recent years an extensive demand has arisen because of the desire for improved and dust-free highways.

Explosives. — Thus far we have considered for the most part only the industrial uses of coal tar products. But a second large group of products, explosives, is of great significance for military purposes though of minor importance industrially.

Explosives, in the Western World, date back to the discovery of gun-powder by Roger Bacon in the thirteenth century. No further discoveries along this line were made until the nineteenth century, when gun-cotton and nitroglycerin were introduced. The first coal tar explosive was picric acid, which is made from carbolic acid, in itself a harmless disinfectant. If, however, this is treated with nitric and sulphuric acids, a high explosive is obtained. The latest coal tar explosive is tri-nitro-toluol (TNT), which is safer to manufacture and transport than picric acid, and has consequently largely supplanted the latter. The chief industrial use of explosives is in the mining and quarrying industries.

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[3] A. Findlay, *The Treasures of Coal Tar*, p. 20.

Poison gas. — In this connection may be mentioned the manufacture and use of poison gases during the World War, although they were not derived from coal tar. Gas was first made use of in April, 1915, by the Germans, who introduced chlorine gas and later phosgene, a compound derived from chlorine and carbon monoxide. The gas used most extensively at the end of the war was mustard gas, compounded of chlorine and hydrogen sulphide. In America the compound most extensively manufactured was chlorpicrin. All of these except the first were loaded in shells or bombs, which discharged the poison gases among the enemy.

Fortunately the art of defense kept pace with the art of offense, and as each new chemical gas was detected it became the duty of the chemists on the opposing side to discover methods of neutralizing its effects. The method most generally used was that of gas masks, which were provided with absorbent cylinders to absorb the gas and prevent its being drawn into the lungs when breathing.

The manufacture of dyes from coal tar. — The most important use for coal tar products commercially is the manufacture of dyes. Coal tar dyes are not present as such in the coal tar, but they are obtained from the various constituents of coal tar by a series of very complex chemical reactions.

When the tar is redistilled there are obtained ten " crudes," which are the basic materials for making dyes. These ten primary constituents of coal tar are benzene, toluene, xylene, phenol, creosol, naphthalene, anthracene, methyl anthracene, phenanthrene, and carbazol. It should be noted that not one of these crudes is itself a dye, but all are colorless liquids or white solids. Thus phenol is carbolic acid and naphthalene is used for mothballs. These ten primary products must be converted into secondary products or " intermediates " by further chemical processes which need not be described here, but which consist in exposing them to the action of such chemicals as nitric acid, sulphuric acid, chlorine, and caustic soda. About 300 of these intermediates are in actual use, and from them are produced about 900 different dyes. This shows the complexity of making a dye, a process which may involve as many as twenty different chemical reactions. Great skill and care are required on the part of those making the dyes.

Early use of dyes. — From the earliest times, man, denied by nature the varied and gorgeous colorings of birds and animals, has used coloring matters derived from the vegetable, animal, and mineral kingdoms for staining his body and dyeing his garments and for decorative purposes. In the primitive state, he colored his own body and what clothing he possessed; but as civilization advanced household articles and buildings as well as clothing became the objects which man chose to adorn with various pigments.

The limited needs of early man for dyes could be supplied from plants and animals, but to-day the demands for coloring materials are so varied and extensive that other means for obtaining them must be sought. If plants and animals could be relied upon to meet the needs, the cost would probably be prohibitive for a great many of the present uses of dyes.

But to-day, owing to the work of scientists, dyes are relatively cheap and plentiful. They have taken a former waste product of industry, coal tar, and by chemical processes have given to the world a vast amount of wealth in dyes and other products derived from coal tar. Coal tar, in so far as industrial importance is concerned, is to-day one of the most important industrial raw materials and from it are derived more products with a commercial value than from any other product utilized in industry.

Early sources of dyes. — The chief source of dyes before 1856 was various plants, although some of the most famous and most expensive came from animals. The various vegetable products utilized in making dyes include indigo, a native of the tropics; logwood, the world's chief source of black for wool and silk; madder, the root which gives the red dye; alizarin, employed in the production of Turkey red; catechu, a native of both the East and West Indies and which gives a shade of brown that is duplicated with difficulty by coal tar dyes; gall nuts, which are growths on the leaves and branches of trees caused by the punctures of various egg-laying insects, used to produce black and other shades; fustic, a Brazilian wood; young fustic, an Italian shrub; quercitron, the inner bark of dyer's oak of eastern North America; Persian berries; and tumeric from the East Indies, the last five products all giving a yellow dye.

Animal dyes were few in number, being derived from shell fish, insects, and charred bone. The most beautiful and most expensive of all colors was Tyrian purple, obtained from a shell fish in the eastern Mediterranean. Another was cochineal, a carmine dyestuff derived from the body of an insect found throughout Mexico and Central America. This dye was used in coloring the scarlet uniforms worn by the English soldiers at one time. Sepia, another dye, was derived from the cuttle fish.

Modern sources of dyes. — The dyeing materials employed to-day may be divided into three classes: natural dyestuffs, artificial dyestuffs, and mordants. Natural dyestuffs include those of plant and animal origin discussed above; " artificial " dyestuffs those of coal tar and mineral origin; mordants those of vegetable and mineral origin, which are applied in combination with other substances to obtain a better result. Mordants play an intermediary rôle between the fabric to be dyed and the coloring matter. They have a greater affinity for certain fabrics than does the coloring matter to be used and are thus applied to the fabric and with the dye, which is added afterward, form a fast color. The process of mordanting was discovered about 1630 by a Dutch chemist named Drebbel, who accidentally found out that a finer scarlet could be obtained by dyeing with cochineal after the fabric had been impregnated with a solution of tin. A color which will not fade under the action of light and water is thus obtained. The process is important to-day, especially in the dyeing of cotton fabrics which do not hold a color well.

Of these groups of dyes, those derived from the products of coal tar are of much the greatest commercial significance. Because of their almost infinite variety and applicability, their range of color and delicacy of tone, they have almost entirely supplanted natural dyes. Before 1856 there were only about 20 dyestuffs in existence, mostly vegetable matter of uncertain composition. To-day there are over 900 different coal tar dyes in use commercially, and about 6000 different colors and shades have been listed which could be produced if there were sufficient demand for them. The great variety of color and the delicacy of shade, as well as the brilliancy and fastness of aniline dyes, and the simplification in the process of dyeing, have led to the almost complete abandonment of natural dyestuffs. Logwood and fustic, which are used to dye wool, are almost the only ones for which the chemists have not found substitutes. If they be omitted, it is safe to say that 98 per cent of all textile dyeing is done to-day with coal tar dyes.

The discovery of coal tar dyes. — The use of synthetic dyes made from the products of coal tar dates from 1856 when W. H. Perkin, an English chemist, produced the once favorite synthetic dye, mauve, by oxidizing aniline which was in turn produced from the benzol derived from coal tar. Perkin's discovery was accidental, being made while he was endeavoring to produce quinine artificially. He was later knighted in recognition of his work.

Although aniline dyes were discovered by an Englishman, the development and exploitation of the industry were carried on by Germans, due to a lack of initiative and the failure to encourage research on the part of the English manufacturers and to the poor patent laws in force in England.

Other uses for coal tar products. — The products of coal tar have a large variety of miscellaneous uses. Many important and valuable medicines and drugs are to-day compounded by the chemist from coal tar. The manufacture of coal tar medicines began in 1874 when from carbolic acid was made salicylic acid, a rheumatism remedy which had previously been extracted from willow bark. Some of the best known products are aspirin for colds and headaches; phenacetine, antipyrin, and similar drugs for fever; sulphonal, veronal, and other soporifics for putting a patient to sleep; cocain and novocain for use as local anæsthetics.

Another valuable group of products is synthetic perfumes, cosmetics, and flavoring extracts. William Henry Perkin, the Englishman who discovered the coal tar dyes, also made the discovery upon which is based the manufacture of coal tar perfumes. In 1875 he made coumarin, which is the perfume part of the tonka bean, and is used for flavoring tobacco, in the manufacture of perfumes, and as a substitute for vanilla in cheap extracts. The real vanilla flavor, or vanillin, was made about the same time by a German chemist, Tiemann. To-day most of the vanilla ice-cream, soda water, and similar things are flavored by the synthetic chemical flavor rather than by the extract of the vanilla bean. So too most of the perfumes sold under the attractive names of heliotrope, lilac, honeysuckle, rose, etc., are not produced from these flowers but are compounded from coal tar products. Instead of using fresh flowers, the chemist distils the essences of the dead flowers of a millenium ago.

Coal tar products are also used in coloring foods and drinks; about 500,000 pounds of dyes are used annually for this purpose in the United States. The red color of frankfurters and the yellow color of butter substitutes are due to the chemical coloring matter put in them. The characteristic color of orangeade and other soft drinks is due to the dyes used in their manufacture.

Dyes are also employed for bacteriological, photographic, and therapeutic uses, and in making inks. In bacteriology dyes are used to stain bacteria, thereby facilitating examination and identification of different bacteria. The shape, size, and structure of stained bacteria are more visible under a microscope than of an unstained one. In photography dyes make plates and films more sensitive to light rays of particular colors. Some dyes have antiseptic and healing qualities and attempts have been made to apply them to the cure of certain diseases. Blue and black writing ink, colored inks and copying and hectographic inks have dyes as one of their constituents.

Saccharin, another coal tar product, first discovered by Dr. Ira Ramsen of Johns Hopkins University, is several times sweeter than sugar and is substituted for sugar in certain cases. It lacks nutritive qualities, however, and therefore will not fulfill the function of sugar as a food.

The importance of the dye industry. — Because of the close relationship existing between the distillation and manufacture of dyes and other coal tar products on the one hand and the manufacture of explosives and poisonous gases for use in modern warfare on the other hand, the synthetic dye industry has come to be regarded as a key industry by most nations — an industry important in a scheme for national defense and one which should be encouraged in order to make each country independent in regard to a supply of these materials.

The early success of Germany in the World War was largely due to the development of the chemical industry in that country, and the basis of her large chemical industry was the manufacture of coal tar products. In no other way would a large chemical industry be possible, because there would be but little upon which to work. There must be an industry large enough to attract and furnish steady employment to a large number of trained chemists. The manufacture of coal tar products, in combination with the many industrial uses found for them, has done this. Thus when such a country goes into war it has a large force of chemists which can be put to work making war materials. This

Germany did in the manufacture of poisonous gases early in the World War.

Vital as explosives and poisonous gas may be in a scheme of national defense, the peace-time uses of coal tar products are much more important economically. The industrial applications of coal tar are numerous and valuable; the manufacture of aniline dyes and artificial perfumes has introduced new beauty and sweetness into the world and has improved our æsthetic sense; and the discovery of medicines and drugs has lengthened human life and reduced suffering. Few products have such a long or varied list of uses as has coal tar.

Conclusions as to coal tar products. — This industry stands in marked contrast with the iron and steel industry, which is the personification of great machines and elemental forces. Here is comparatively small production of highly valuable articles by careful methods involving long and painstaking research. Of all the industries thus far studied it illustrates best the application of science to industry, and the growing need of a closer alliance between the two. Instead of depending upon a vast store of rich natural resources, the coal tar industry utilizes what was formerly a waste product.

Such an industry requires large capital, for it involves considerable risk of failure, long-continued research which is not always successful, and large expenditures for laboratories and personnel. It can best be carried on by large corporations rather than by numerous small producers. As a matter of fact the industry is concentrated in the hands of a comparatively small number of large companies. This is especially true of explosives. The coal tar industry is the sort of industry which we may expect to see develop more generally, with the maturer industrial growth of the United States and the gradual depletion of its natural resources.

SUGGESTIVE QUESTIONS

1. What is the rank of the various countries in the production of coal tar and its products?
2. How does the quality of American coal tar dyes compare with that of the German?
3. How do dyestuffs rank among the imports of the United States from Germany?

4. Is there any relationship between the coal tar and dye industry of Germany and her early success in the World War?

5. From what different industries is coal tar obtained?

6. Is there any similarity between the processes in refining petroleum and in distilling coal tar?

7. For what are ammonia salts used?

8. Why has the United States been so slow in starting to save the by-products of coal?

9. List some of the articles that you use daily of which coal tar products are a constituent.

10. Do coal tar products compete with lumber?

11. What proportion of the clothing which you are wearing is dyed?

12. There has been a very noticeable increase in the last decade of the bright colors in women's and girls' dresses, and in men's shirts and ties. How do you account for this?

13. List some of the materials obtainable locally which might be used as dyes if the coal tar and other chemical dyes were exhausted. Would they be as satisfactory?

14. Perform the experiment described on page 507.

BIBLIOGRAPHICAL NOTE

The majority of books about coal tar and dyestuffs are too technical to be of value to the general student unless he has had several courses in chemistry. A few, however, are written so that they are fairly easy to understand. Most of the books on the subject are of German or English origin and it is only recently that the industry has received much attention in the United States. The different chemical journals and the *Scientific American* contain abundant recent material.

The standard work on the fundamental process of coking, with some account of the recovery of by-products, is H. C. Porter, *Coal Carbonization* (New York, 1924). Already somewhat out of date is V. B. Lewis, *The Carbonization of Coal* (New York, 1912). Authoritative works on coal tar and its products are G. Lunge, *Coal Tar and Ammonia* (London, 5th ed., 1916), and F. H. Wagner, *Coal Gas Residuals* (New York, 1914). Another good American book is I. W. Fay, *Coal Tar Dyes* (New York, 2nd ed., 1919). These books are extremely technical. Less technical, though not so good, is A. R. Warnes, *Coal Tar Distillation* (London, 3rd ed., 1923). *Coal Tar and Some of Its Products* (London, 1919), by the same author is equally readable. A. Findlay, *The Treasures of Coal Tar* (New York, 1917), is a short but good American book covering the same material, as is also J. C. Cain, *Manufacture of Dyes* (London, 1918). T. Beacall, *Dyestuffs and Coal Tar Products* (London, 1915) is similar to but more detailed than the two books just mentioned. A popular and elementary book on drugs is H. C. Fuller, *The Story of Drugs* (New York, 1922). Interesting and non-technical chapters on the subject will be found in E. E. Slosson, *Creative Chemistry* (New York, 1921) and H. E. Howe (Ed.), *Chemistry in Industry* (New York, 1924).

CHAPTER XXXV

ASSEMBLING INDUSTRIES: AUTOMOBILES

An assembling industry. — Assembling industries are those in which the different parts of the finished product are made individually, sometimes within the factory making the finished product, but more often in factories specializing on a particular part, and then brought together and combined, forming finally the object desired. The best example of such an industry is the manufacture of automobiles. But few, if any, automobile manufacturers make all of the parts which go into an automobile. They depend for them upon companies which make these products in large volume for several automobile factories. Many automobile plants would not be considered factories in the ordinary sense of the term. They do not carry a product through all the stages from the raw material to the finished form, but only put together the products which are made by other factories. Such plants have more of the characteristics of a building or construction industry. But most automobile plants make some of the products which they use and thus are factories in the true sense of the term. Other important assembling industries are the manufacture of watches, bicycles, shoes, pianos, electrical equipment, machines, locomotives, and ships.

The first automobiles were made practically by hand. This meant the constant testing and measurement of parts to ascertain whether they conformed to specifications, the polishing or filing or packing of parts to make them fit, and the repeated rehandling of parts in this process of trial and error. This was a laborious and costly process and the cars thus produced were correspondingly expensive. If they were to be brought within the reach of the motorist of moderate means, it was clear that some method would have to be devised by which the cost of production could be greatly reduced. Such methods had already been successfully introduced in the watch and bicycle industries and offered a model for the new automobile industry. But the successful application of machine methods depended upon production on a large scale, and it was by no means certain that sufficient demand existed for a medium- or low-priced car to warrant building in large numbers. Production on a large scale involved, moreover, specialization and standardization of parts, and this in turn required elaborate and expensive machinery, all of which called for the investment of large amounts of capital. The introduction of quantity production waited, therefore, until the experimental stage had passed and there was assurance of a large potential demand.

Interchangeable parts. — An automobile is made up of a number of parts, engine, chassis, wheels, body, etc. Each of these in turn is composed of cylinders, pistons, connecting-rods, crankshafts, camshaft, crank-cases, transmission gears, axles, steering knuckles, nuts, valves, clutches, radiators, tires, rims, tubes, fenders, seats, doors, windshields, and many other parts. If the assembling method is used in the manufacture of the automobile it is clear that each part must be an exact counterpart of every similar part, so that they are absolutely interchangeable. There will be no time to pick and choose, to try to fit a piston-ring in a piston by rejecting one and selecting another, but the workman must pick up from a heap of a hundred the first one that comes to hand and must put it in its place.

The great advantage of interchangeable parts is that every part must be true to the fractional part of an inch, that it is bound to fit its fellow, and that it can be freely interchanged with other similar parts. When the assembling takes place the needed parts may be drawn at random from the promiscuous heaps, and put together with the full assurance that they will fit. In order to ensure this result the American manufacturer spares no expense in installing and perfecting the machinery which will do the work best. A die for pressing a special part may cost $800, but he will not hesitate to purchase it if it is an improvement upon the one in use. This, however, can only be done if production is carried on upon a large scale.

Standardization. — Some automobile manufacturers advertise " custom-built cars," which are usually custom-built bodies with standardized motor and chassis, but these are very expensive. In all the cheap and moderate-priced cars all the parts are standardized, that is, made after a certain pattern designed and set up for the particular car. So long as hand methods are used in producing goods a different article may be made for each customer at about the same cost, but when machinery is introduced variation is limited by the expense of changing the machine or perhaps of making a new one. It is costly to draw the specifications for a new design, it is expensive to make a pattern or model, and after a new part has been cast according to the new pattern, lathes and boring and drilling machines must be adjusted and set to finish the rough part. A large portion of the cost of special products is getting ready, while in the case of a standardized product this preliminary work does not have to be repeated. Once the pattern has been made and the machines got ready, thousands of identical units can be turned out at a decreasing cost per unit.

In all large automobile plants there is consequently a tendency to concentrate on one type or a few types. " Variety is the curse of standardization — a deadly brake on the output." Thus in the most highly standardized of all automobile plants — the Ford factory — only two models of chassis are produced, the pleasure-car and ton-truck models. Each chassis is an exact duplicate of all its fellows down to the linch pins, in spite of the fact that it serves for five standard models, ranging from a sedan to a delivery car. The motor is the same for all the cars. Since one chassis only is produced for each type, standardized parts by the thousands, and even millions, are manufactured without changing a pattern, readjusting a lathe, or resetting a machine. The testing and measurement of parts to ascertain whether they conform to specifications is also reduced to a machine-like process.

Automatic machinery. — In the assembling manufactures the utmost degree of precision in each part must be assured. For this, hand methods are not sufficiently accurate, so automatic machinery goes hand-in-hand with standardization. As an illustration a brief description of the methods used in the Cadillac factory may be quoted: [1]

" Automatic milling machines reduce production cost in the machinery of such parts as crank-cases, transmission-cases, spring-hangers, fly-wheels, and so on; automatic gear-cutting tools turn out all transmission parts, camshaft, steering and pump gears by the thousand; powerful milling machines finish three sides of ten blocks of four-cylinder motors, cast in one piece, at one operation, and so accurately that the error cannot exceed the one-thousandth of an inch; and so on. . . .

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[1] F. A. Talbot, *Motor Cars and Their Story* (London, 1912), pp. 101–103.

"In this (Cadillac) factory the insistence upon accuracy may be seen in its most perfect form. In this vehicle there are more than 250 parts, which demand more than 400 operations, not one of which is permitted to err more than the one-thousandth part of an inch from the prescribed limits of measurement. . . . To realize what this permissible error means it may be mentioned that the one-thousandth part of an inch is less than one-half of of the proverbial hair's breadth!

"When it comes to the valve motion the Cadillac Company is even more particular. The correct operation and timing of the valves is vitally dependent upon the accuracy of the cams and camshaft, so in consequence the cams and the shaft are ground to the one two-thousandth part of an inch. To secure such fine perfection in measurement demands the use of first-class tools and equipments. . . . In the manufacture of this car the parts pass through one or more of no fewer than 500 special automatic labor-saving machines, to ensure more delicate precision than emanates from the best of human aptitudes. At the same time some of these machines will turn out ten times the volume of work, and more precise too, than is possible by hand labor. . . . The equipment is among the finest in America for the production of automobiles, including over 100,000 tools, dies, jigs, fixtures, etc., of which some 20,000 were specially made for the production of this popular car."

Quantity production. — Automatic machinery, standardization, and interchangeable parts are the conditions which must be met if assembling manufacturing industries like watch making or automobile building are to be established. But all of these are preliminary operations to provide the parts which the assembling industry uses. These parts may be, and often are, made in other factories and by other manufacturers, and are furnished to the assembling plant. This is almost invariably true of motor accessories, such as tires, speedometers, and similar parts. The majority of companies make less than 20 per cent of all the parts included in their cars.

The reason for this condition lies in the advantages derived from large scale production. A good illustration may be found in the production of tires. The Ford company might make the tires with which the new cars are equipped. But this is not the total amount of such tires required. The Ford cars already in use require a large number of tires annually and there are other makes of cars which use the same sized tire. If an automobile manufacturer wished to establish a tire factory of sufficient size to satisfy this total demand, he could manufacture as cheaply as an independent tire manufacturer, but if he wishes only to equip his own output, the better and cheaper thing to do is to buy the tires. The advantage lies with the large scale producer.

This practice does not destroy the individuality of the various makes of cars because the engineers of individual assembling companies draw their own specifications, and the parts made must conform to these ideas, but it does shift the burden of manufacturing that particular product and the overhead expense of conducting separate factories to those concerns which specialize in such lines of production.

Thus far there has been described only the production of the parts which enter into an automobile, and which, as already stated, may be produced in other factories. We are now ready to turn to the assembling industry itself. The most striking feature of this type of manufacturing is the progressive method of assembling. This method originated in the automobile industry,[2] and proved so successful that it was adapted to meet the requirements of other lines of manufacture.

Factory coördination. — In a modern factory all of the departments are united and coördinated into a smoothly working whole by a central office. Between departments and between individuals within each department there is a continuous and circulatory interchange of commodities and services which constitutes the life blood of the factory. Usually this circulatory interchange of commodities is so rapid and constant that the article being worked upon is not allowed to stop in its movement through the factory. Each workman performs his function as the product moves slowly by him. In some industries the product is not handled by the worker. Raw material enters at one end of the factory and comes out a finished product, packed and ready to ship, at the other — all without the touch of human hands.

In assembling industries and especially in the manufacture of automobiles this circulatory movement is most striking. An endless chain or conveyor drags along, at first, the elementary parts of a frame. As this frame passes workman after workman, each with a particular function to perform, one part after another is added until by the time the end of the building has been reached an automobile, able to move away under its own power, has been put together.

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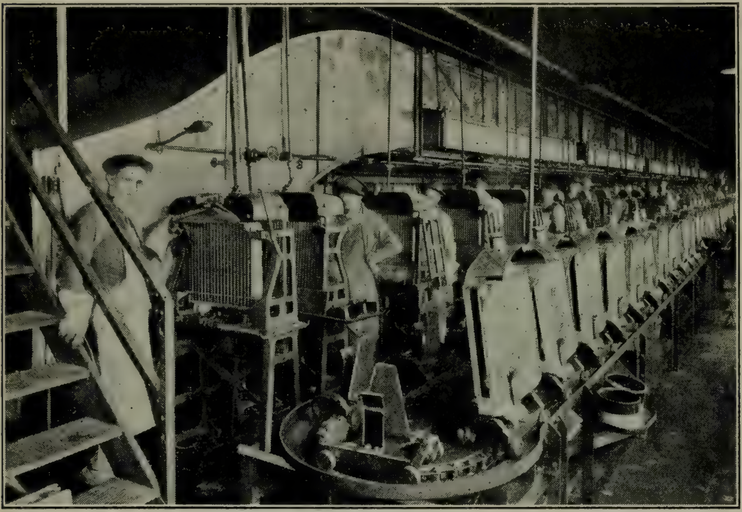
[2] E. K. Hammond and F. D. Jones, *Automobile Shop Practice* (New York, 1923), p. 278.

Obviously, for the success of such a system, great care must be exercised in planning and designing the plant and the methods of the different operations and in maintaining a supply of the necessary materials. Great responsibility rests upon those who are responsible for the various departments. Poor designing and planning may mean inefficient production — the loss of time, capital, and labor power. If a supply of materials is not always at hand the whole process must stop. Everything goes according to schedule and one who cannot maintain his part of the schedule must give his place to one who can.



Radiator Manufacture

There is a very large number of parts in a radiator, and as many as 140 distinct operations are involved in its manufacture. This cut shows the conveyor system in the Ford plant, carrying an endless line of radiators to be soldered.

Plant layout. — If the circulatory or progressive movement of the article to be assembled is to proceed smoothly and rapidly, the plant must be laid out in such a manner that the work may pass from one operation to another in orderly sequence. With a scientific plant layout it is possible to plan and arrange a program of work for a period of time, as a week, a month, or longer. After methods, tools, rate of production, etc., have been standardized, the work for each machine can be laid out for a period and the product go through each operation according to a pre-arranged schedule. The chief consideration is to get each part finished in time for the assembly operation. In no industry is plant layout of more importance than in the automobile industry, for here the method of progressive assembly — the flow-sheet design already described in the milling industry [3] has been carried farthest.

This may be illustrated by an example. Let us assume that an automobile plant, running one shift a day, has an output of 20,000 cars per annum. This means about one car every five minutes, or a " five-minute schedule." If one part only is required per car, as a transmission gear, the department providing that part may work on a five-minute schedule, but if two parts are needed, as axles, this department will probably be arranged on a two-minute schedule, allowing for spares, defective parts, and similar contingencies. It is clear then that the entire plant must be arranged in such an orderly sequence and the different departments so scheduled to provide their particular parts that the work as a whole shall not be slowed up. If this were not done, some machines and workmen would be standing idle at times, waiting for the slower departments to catch up. In an assembling industry it is essential that there be no stoppages, but that the work proceed without interruption.

Assembling the engine. — For the purpose of illustrating the assembling type of manufacturing we may assume that all the separate parts are made in other factories and that the automobile plant is engaged solely in the business of assembling these parts to build finished automobiles. But as the modern motor car is a complex mechanism, it is evident that the different units must each in turn be assembled before they are brought together.

Of all these units the engine is the most vital, so the description may well begin with this. Before the factory can begin operations buildings must have been erected and a complete supply of engine parts have been accumulated. These parts may be conveyed from the storage room to the workmen engaged in assembling the engines by trucks, but in the best plants trucking or carriage by hand is avoided as much as possible. Probably an apron conveyor or endless belt or moving platform is used, upon which are placed the various parts needed in the construction of an engine in the sequence in which they are to be assembled. Methods differ in different plants, but in one of the plants devoted to the building of a low-priced car, stations are established at intervals along the conveyor at which are performed certain specified steps in assembling the engine. When the partially assembled engine part reaches one of these stations it is lifted off the conveyor and the next part attached, after which it is placed back on the conveyor and goes to the next station, where another operation is performed. After the partial assemblies have reached a point where they are too heavy to lift on and off the conveyor they are slid along metal-faced benches, but the same method of progressive assembling is still followed. When the engine has been completely assembled an overhead trolley picks it up and carries it to the department where the final assembling of the cars is done.

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[3] See p. 450.

Assembling other parts. — The same general method is used in mounting such auxiliary apparatus as windshields, clocks, speedometers, seats, etc., on the body. The body itself passes in a continuous line of travel through the shop, and during its progress the various parts are put in position by workmen, each of whom performs the same operation for each successive body. At the same time the seats and insides of the bodies are upholstered, so that when the bodies reach the end of this department they also are ready to be assembled into finished cars. At this point the body is ready to be placed on the chassis to make the finished car.

Wheels, rims, and tires are being assembled in still another department, fenders and wheels are being dipped in enamel and baked in still another, and other units got ready for the final assembling in still others.

Progressive methods of assembling complete cars. — An excellent description of the final process of assembling the various parts and units into a complete car has been given in a recent authoritative book and may well be quoted here: [4]

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[4] E. K. Hammond and F. D. Jones, *Automobile Shop Practice* (New York, 1923), pp. 290–291.

"The same general method of assembling is applied in the majority of plants engaged in automobile manufacture, although details naturally differ in each plant. In general, the method consists of starting the chassis at one end of a track, down which it is carried between two lines of men, each of whose duty it is to put a specified part on the partially finished car as it passes by the point where he is employed. In factories where the assembling department has been carefully organized, it is a practice to have a power-driven conveyor carry the cars along this assembling track, so that a pace is set at which the men are compelled to work. In the Willys-Overland plant, this pace has been carefully determined, so that by a proper adjustment of the number of men employed at each station, none of those working in the assembling department are required to exert themselves to an extent which would be detrimental to their health. At the same time, the establishment of a uniform rate of working by all of the men protects the employer against the dishonesty of those who might otherwise be inclined to shirk their work. In most places where a power-driven progressive assembling equipment is used, the balance between the speed of the conveyor and the number of men employed has been worked out with such a degree of nicety that it is necessary to have substitutes stationed at intervals along the line for the purpose of taking the place of any man who has to leave his work temporarily. These substitutes have been trained in various parts of the work of assembling, so that they are able to give efficient service in a number of these specialized tasks without delaying production.

Advantages of assembling by progressive method. — "It is coming to be generally recognized by progressive manufacturers that there are few methods which are capable of effecting greater savings in production costs than a properly worked out application of the method of progressive assembly. Although this method was originated in the automobile industry, its field of usefulness is by no means restricted to plants engaged in the production of motor cars. For these reasons, it may be well to call attention at this point to a modification of the power-driven assembling conveyor which has been found to give satisfactory results in several plants. Instead of having the conveyor moving continuously at a predetermined speed, this modification consists of having a control station at the end of the assembling line, where means are provided for starting the conveyor to advance all of the work on the assembling line to the next station, after which the conveyor is stopped for a sufficient length of time to allow the next assembling operation to be performed.

" As rapidly as the men at each station complete their work, a signal button is pushed, causing a light to flash under a number designating that number on an indicator board, which forms part of the equipment of the control station. As soon as all of these lights have been turned on, it indicates to the man in charge of the control station that the work of assembling has been completed at every station along the line. When the last signal light appears, he throws over the control lever to advance the work to the next assembling station. A careful record is kept of the order in which each station along the assembling line completes its work. This is an important source of information for the production department, as a study of this record will sometimes show that one station along the line is consistently the last in finishing its work. When the records reveal such a condition, an investigation is immediately started to ascertain whether the men employed at that station are taking too much time over their work, or whether they have too much work to do in a specified time. In either case, the necessary correction will be made to enable this assembling station to complete its work with the required degree of rapidity."

Preliminary running test. — During the process of assembling the car a supply of gasoline is pumped into the gasoline tank sufficient to give the car a brief running test before it leaves the assembling line. The car has been carried on a conveyor with the wheels lifted off the floor during the assembling process, but when it comes to the end of the assembling track it is run off onto a platform on its own wheels. Beneath this platform there are mounted rollers on which the rear wheels are placed; these are given a turn so as to start the motor, and then the driving wheels rotate without advancing the car. If this test is satisfactory the car is now driven out of the building under its own power, ready for the final test before shipment. It was formerly the practice to subject each car to a gruelling road test, but the modern practice is to reduce this to a minimum for the purpose merely of detecting defective parts. If an automobile or machine-made watch will run after being assembled, this is accepted as *prima facie* evidence that it is satisfactory. Sometimes even the preliminary test is omitted.

Assembling a Ford car. — A picturesque description of the progressive method of assembling, which illustrates well the driving character of the work, may be given by way of summary. This is a description of the Ford assembling plant in 1914, but further improvements have been made since that time.

" Fifteen thousand men work in gangs on the track system. Each gang, and each man in each gang, has just one small thing to do — and to do it over and over again. It's push and hustle and go. The man behind may shove his work along to you at any moment — you must not hold him back; at any moment the man in front may be ready for another piece to work on — he must not be kept waiting.

" Up one line and down another goes a continual stream of motor parts in process of assembling. One man fits the parts together so that the bolt holes come right. The next has a pan of nuts before him and all day long he scoops them up and with his fingers starts them on the thread of the bolts. The next man gives them the final twist that makes them tight.

" Over in another part of the factory there are four or five parallel tracks. On every track are a dozen automobiles in all stages of being put together. Each is slowly moving from one end to the other, and — like a snowball rolling down-hill — gathering itself together as it travels, until with a short snort and a whir it dashes out of the door on its own power. . . .

" Piled up along the way are the different parts, each to be added as the growing machine passes by. Each man does his part, and gives it a shove. First, to a mere skeleton of a frame, two men attach the rear axle. They fasten it in haste and give it a push — some one else will tighten the bolts. Three men seize it and in a moment the front axle is in place and the four wheels put on. It's easier to move now; a touch sends it on to another gang of three, who put on the truss-rods and tighten things up all around.

" Another shove and it goes to where a motor is dangling from chains, directly over the track. A word from some one and down comes the motor to its place, and bolts go in and on goes the machine. Then comes the steering gear, and the control levers — on again, and from overhead a hose is pulled down and a gallon of gasoline squirted into the tank. One more shove and the rear wheels drop into a slot where there are rapidly revolving pulleys. The wheels begin to whirl — the motor starts — a man seats himself on the tank, grasps the wheel and cuts loose, and with a snort and a cough, out the door they go. What was, ten minutes ago, a pile of rods and gears and lifeless steel is now thrilling with power. A car came through that door every twenty-four seconds Saturday morning, January 24 . . . ."[5]

As a result of the methods described in the preceding paragraphs a new record for speed in car assembling was established in 1914. In the Ford factory in 1912 fourteen man hours were required on the average to assemble a car. In 1913 this time had been lowered to nine hours, but in 1914 it was further reduced to two hours, with a special record of 84 minutes for putting together one car. But a still more notable achievement has been that of shortening the whole production cycle, from the smelting of the iron ore to the delivery of the finished car. According to the Ford Motor Company, " ore delivered at the River Rouge docks Monday has been cast, machined and assembled as a unit, then shipped to a branch 300 miles distant to be assembled into a finished car and sold to a dealer and by him to a customer by Thursday night of the same week. This was an actual performance in 1923."

Labor in the manufacture of motor vehicles. — Because of the urgent demand for their product and because of a shortage of skilled labor, the manufacturers of motor vehicles have specialized their processes to a high degree, employing machinery where it is at all possible. As a result of these facts, the bulk of labor employed in the industry is relatively low skilled; and in addition, most of the processes involved do not require a long period of apprenticeship. A person can become proficient in them within a few weeks' time.

The division of labor has been carried very far. In a typical automobile there are as many as 67 different occupations and these occupations, classified according to the nature of the work, may be divided into four divisions; machine tool occupations, assembling occupations, finishing occupations, and inspecting and testing occupations.

Machine tool occupations. This division includes all of the actual manufacturing occupations and ordinarily gives employ-

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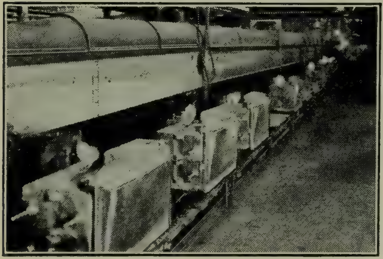
[5] J. A. Fitch, in *The Survey* (Feb. 7, 1914), pp. 545–550.

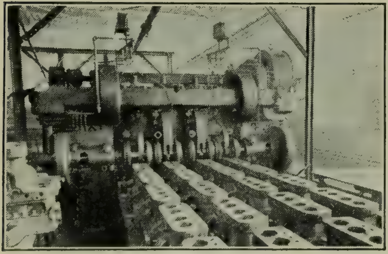
SHORTENING THE PRODUCTION CYCLE[6]

MONDAY 8 A.M. — After a trip of approximately 48 hours from Marquette the ore boat docks at the Fordson Plant. Hulett unloaders start removing the cargo, which is transferred to the High Line, and from there to the skip car which charges the blast furnace. By continuous process this takes 10 minutes.

TUESDAY 12:10 A.M. — Sixteen hours later the ore has been reduced to foundry iron. It is then cast into pigs and sent to the foundry, where, mixed with certain proportions of scrap, it is remelted. This takes about four hours in all.



TUESDAY 4:10 A.M. — As the conveyor brings the moulds past the pouring station the hot metal is cast into cylinder blocks. These then go to the shake-out station and are taken away to cool and be cleaned. The cooling and cleaning process requires about five hours.



TUESDAY 9:10 A.M. — The casting now goes to its first machining operation. There are 44 operations in all, all of which are done in approximately 100 minutes. All these are performed in the foundry building — a departure from conventional foundry practice, but in line with the Ford method of continuous operation.

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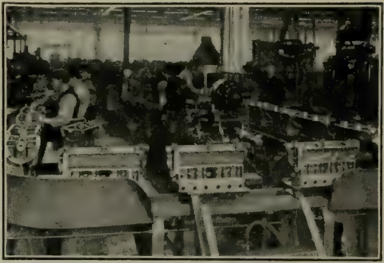
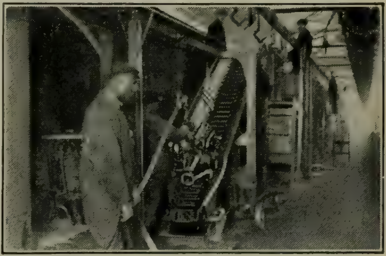
[6] Courtesy of the Ford Motor Company.

Shortening the Production Cycle (Continued)

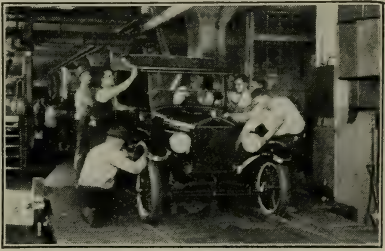


Tuesday 10:50 a.m. — About 10:50 o'clock the motor block is ready for the assembly line. Ford mechanics have reduced the time required for motor assembly to an average of 121 minutes. This includes everything, even an electrically controlled block test. Except for "running in" the motor to loosen it up everything is done "on the move."

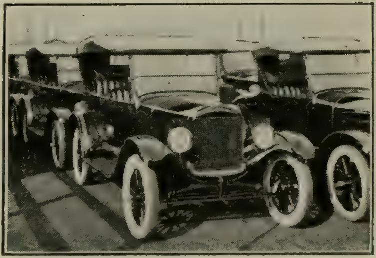


Tuesday 12:50 p.m. — The finished motor coming out over a trunk line conveyor is loaded into a freight car with the aid of the device illustrated and shipped to a branch for assembly into a finished car. A constant stream of freight cars leave the plant day and night.

Wednesday. — Arriving at the branch plant the motor is unloaded and sent to its station on the final assembly line. These assembly lines are standardized the world over and represent specialized workmanship at the peak of efficiency. In 4 hours the car is ready to be driven away.



Wednesday 12 Noon. — Long before noon the dealer will have taken delivery of the car and paid for it. In the case of driveaways the dealer often brings his customer to the plant and closes the deal there. Here is a conversion of raw material into cash in about 52 hours. Of this 52 hours, 15 are consumed in shipping and handling. Even this record-breaking cycle is often shortened, for if the Detroit Branch had made the assembly, much of the shipping time would be saved.



ment to about 54 per cent of the total working force in a factory. The use of automatic machinery and the division of labor have gone farther in this department than in any of the other three. Because of this, the degree of skill required is low, the technical knowledge and skill having been transferred to the engineering and designing departments where nearly all of the thinking, planning, and experimenting are done. As a result, the mental work required of the ordinary laborers is that of carrying out simple instructions. In this group are also found a few skilled and highly specialized trades such as molding and core making but they give employment to only a few men.

Assembling occupations. Nearly all assembling is primarily hand work. It requires little in the way of technical knowledge but demands great care, close attention, constant activity, and considerable manual dexterity. Each assembling operation has its own peculiar characteristics. Some require only fitting a part in a certain place while others include both fitting and nice adjustment.

In assembly operations, specialization is carried to the highest degree. A separate group specializes in assembling each unit of an automobile as motor, gears, body, chassis, etc., and each person in a group specializes upon some one part of the unit. One person's task may be simply to put a bolt or key in place or to turn down a nut on a certain bolt. Some of these assembly operations, as motor or transmission assembly, require considerable experience and a relatively high degree of skill, but the number engaged in such operations is small. Most assembly operations are of such a nature that they may be learned in a day or two.

The assembly operations involved in setting up an automobile may be divided into three groups. In the first group are performed the simpler operations such as attaching fenders and mudguards and fitting the axles to the chassis. Each operative's work is laid out for him and he simply fastens the part in the proper place. In the second group are found the assemblers of such parts as the steering column, transmission, clutch, and motor. Here a knowledge of the parts and their function is necessary because each worker must deal with a complete mechanical unit. Each piece must be fitted and adjusted so as to operate with the least possible friction.

The third group fits the body, hangs the doors, and performs other final operations. The chief requirements here are care and skill, so as not to mar by a careless stroke any finished part of relatively high value.

Finishing occupations. Painting and cushion-back-making are finishing occupations. The work is specialized and requires considerable skill. The painting of an automobile is divided into seven occupations. Four of these — stripers, finish varnishers, hardwood finishers, and enamelers — require skilled workers; the other three only semi-skilled.

Inspecting and testing occupations. Because automobile factories purchase most of their parts from other factories, each piece must be inspected and tested as soon as received, to see whether it is of the standard required and for defects. Minor defects are corrected in a small machine shop in the plant. Trained workers are also required for inspecting the finished automobile and giving it a road test.

The rise of the motor vehicle industry. — The rise and development of the motor vehicle industry has been the most phenomenal and rapid of any industry, especially in the United States. The first motor-propelled road vehicle was invented by Cugnot in France about 1765, being a steam-driven vehicle designed as a tractor for field guns, but it was so clumsy and difficult to steer that little use could be made of it. There were subsequent improvements and inventions during the next century and a quarter but they were without practical application. The first road vehicle driven by an internal combustion engine was invented in Germany in 1885, but the first modern automobiles were made in France in 1891. By 1900 they were established in the United States. Since that time, and especially since 1912, development has been rapid. Between 1895 and 1912, only 1,000,000 cars were manufactured in the United States, but since the latter date over 20,000,000 have been made. In 1924 the manufacture of motor vehicles was first in value of product among the manufacturing industries of the country with a product valued at $2,328,066,000. The slaughtering and meat packing and petroleum industries were second and third with a product valued at $2,200,942,000 and $1,727,440,000 respectively.

Reasons for the preëminence of the United States. — Several reasons can be given for the rapid development of the motor vehicle industry in the United States and the rise of the country to first rank as a producer of motor vehicles. In the first place such a means of transportation filled a want and filled it well. In this country, distances are long and sections are undeveloped. This impeded marketing under slower methods but with an automobile or truck, distance is not an obstacle for relatively long distances. Under such conditions, any cheap method of transportation was sure to be adopted. People who formerly were practically without markets for certain products which could be produced now, with motor vehicles, have a market close at hand, commercially speaking.

Another reason is that the automobile was invented after business methods and machinery had been well standardized. Automobile manufacturers did not have to start in and build their whole industry from the beginning; they had the experience and methods of others as a foundation. Rather than build up new methods and machinery they could improve on the ones already in existence. The automobile also came into use when the machine tools had reached a stage of considerable importance and the ability of their designers was well recognized. These designers could be employed in similar work in the automobile industry. Thus, the skilled designer and engineer with his technical knowledge, and the business manufacturer with his knowledge of business methods coöperated and brought about the rapid development of the industry.

Other factors in the development of the industry are the abundance of good raw materials, standardization and quantity production, and the ingenuity of the people and their willingness to adopt new methods.

The use of motor vehicles has become a necessity in many instances. In various ways they are an aid to the productive processes. Sixty per cent of all such vehicles in the United States are used for business purposes. The number of people traveling in automobiles now surpasses the number traveling in railway cars.

SUGGESTIVE QUESTIONS

1. Describe the processes in the assembling of some product which you have observed.
2. Could you assemble a radio outfit if you were given the money to buy the parts?

3. Some firms advertise " knock-down garages," " ready cut houses," etc. What are these?

4. Under what conditions would it be profitable for an automobile manufacturer to make all of the parts needed in his own factory?

5. If you were going to build a garage how much time would you spend in drawing plans, taking measurements, and getting ready, as compared with the time spent in actual construction?

6. The Haynes automobile, formerly made at Hammond, Indiana, has gone out of existence. How would you explain this?

7. What is meant by the expression, " an orphan car " ?

8. Explain the value of interchangeable parts in connection with farm machinery.

9. What do you understand by standardization? Give an example of its benefits.

10. How many service stations are there in your community ready to supply spare parts, in case of accident to a car?

11. Describe the automatic machines that are used in manufacturing automobile parts.

12. What is meant by " flow-sheet design " ?

13. Why is there such a variety of " makes " and models of automobiles? Is there any reason to believe that this variety will be lessened in the future?

14. What is the number of automobiles in the United States at present?

15. Why are the people of the United States the greatest users of automobiles in the world?

BIBLIOGRAPHICAL NOTE

The automobile industry, the most important of the assembling industries, is so new that not many books have as yet been written about it. The best material is therefore found in technical and engineering journals. The best of these is *Automotive Industries*.

Books which describe in detail the methods of the automobile factory are H. L. Arnold and F. L. Faurote, *Ford Methods and the Ford Shops* (New York, 1915); and E. K. Hammond and F. D. Jones, *Automobile Shop Practice* (New York, 1923). Similar in character is the book by H. L. Barber, *Story of an Automobile* (Chicago, 1917). The history of the industry is given in J. R. Doolittle, *The Romance of the Automobile Industry* (New York, 1916), an elementary and voluminous but poorly organized book. The same material is better treated in F. A. Talbot, *Motor Cars and Their Story* (London, 1912). A condensed chapter on assembling industries is found in G. S. Watkins and M. H. Hunter, *The Background of Economics* (New York, 1923). An excellent chapter is also given in J. C. Duncan, *The Principles of Industrial Management* (New York, 1925). The statistical position of the automobile industry is found in *Facts and Figures of the Automobile Industry* (National Automobile Chamber of Commerce, New York, Annual).

PART VII

THE PROCESSES OF EXCHANGE

CHAPTER XXXVI

TRANSPORTATION AND COMMUNICATION

The need for markets. — Previous chapters have described the production of various raw materials and the methods of their conversion into finished commodities ready for the consumer. Each of these stages of production is carried on by groups of specialists who usually confine themselves to a single stage, or perhaps even to a single process in the given stage, receiving materials from antecedent producers and passing on these materials more or less transformed in shape or quality to the next group. Practically none of these goods is consumed by the worker who is engaged in producing them, but all are made to be sold. In their journey from the producer to the consumer they therefore pass through the market, sometimes through several markets. The process of marketing is, however, generally not carried on by the farmers or miners or manufacturers or other primary or secondary producers, but is handed over to other specialists, a tertiary group of producers.

The word " market " originally meant a public place or building where goods were exposed for sale. To-day, however, a market is said to exist when purchasers and sellers of a commodity come together with such freedom of intercourse that they establish a single price at which the commodity is bought and sold. It is evident therefore that there are numerous markets, differing in character and extent according to the nature of the commodities dealt in. The most familiar of these is the retail store where goods of all sorts are sold directly to customers. Between the retail merchants and the manufacturers or producers there are probably wholesale dealers, who buy and sell in a wholesale market. Sometimes these wholesale markets are national or even international in scope, and in them practically a uniform world price, differing only by costs of transportation, is established for a uniform commodity. Some of the staple goods dealt in are so uniform and standardized and in such general demand that special markets are established especially for these, as the Cotton Exchange, Wheat Exchange, Petroleum Exchange, and others. Finally, a highly specialized market exists in every industrial country for the purchase and sale of stocks and bonds and other securities; this is known as the Stock Exchange. These various markets provide the opportunity for the exchange of commodities for money and of money for commodities. Without such an opportunity the highly specialized work of modern industry could not be carried on.

It is evident that these markets serve not merely to distribute finished goods to the final consumers, but are a means also by which producers all along the line can dispose of their products and other producers can obtain these products as their raw materials. As we have seen, very few manufacturers carry the production of their commodities through all the processes from raw material to finished consumable article. Each is usually a specialist in one process. As a result of this specialization it is essential that machinery be provided by which these half-finished goods, as pig iron or steel rods, may be passed on to the producers in the next stage. The market provides this machinery, and it must therefore be regarded as an integral part of the productive process.

The mechanism of exchange. — It is evident that agencies of various kinds are necessary to move the materials and commodities from one stage to another and to facilitate their exchange in the markets. The agencies upon which the organization and functioning of the modern market depend are: (1) transportation, communication, and storage agencies; (2) monetary and banking systems; and (3) merchants and middlemen.

Without these agencies modern industry would be impossible. Specialization of industry and division of labor could not exist, since they depend upon the existence of a market, and this in turn is made possible by cheap transportation. The coördination of many interdependent producers in all stages of production into a unified system requires a mechanism of transport and communication which shall link them together into an unbroken chain. Equally necessary is a monetary and banking system which facilitates the exchange of the specialized products of each worker for the commodities produced by others; this is done by a common medium of exchange and by financial institutions. And finally the directing brains and skill are furnished by other groups of specialists, usually called middlemen, who direct the distribution and marketing of the various products.

Importance of transportation. — If we should follow the life history of any commodity from its production as raw material through the various stages of conversion into a finished good, of storage, and of marketing, we would find that at almost every other step transportation entered in. The accompanying chart, designed to illustrate the stages in the distribution of agricultural products, shows how essential transportation is in the process of production and distribution.

The essential features of this chart may be somewhat abbreviated and stated in slightly different fashion, to bring out more clearly the importance of transportation.

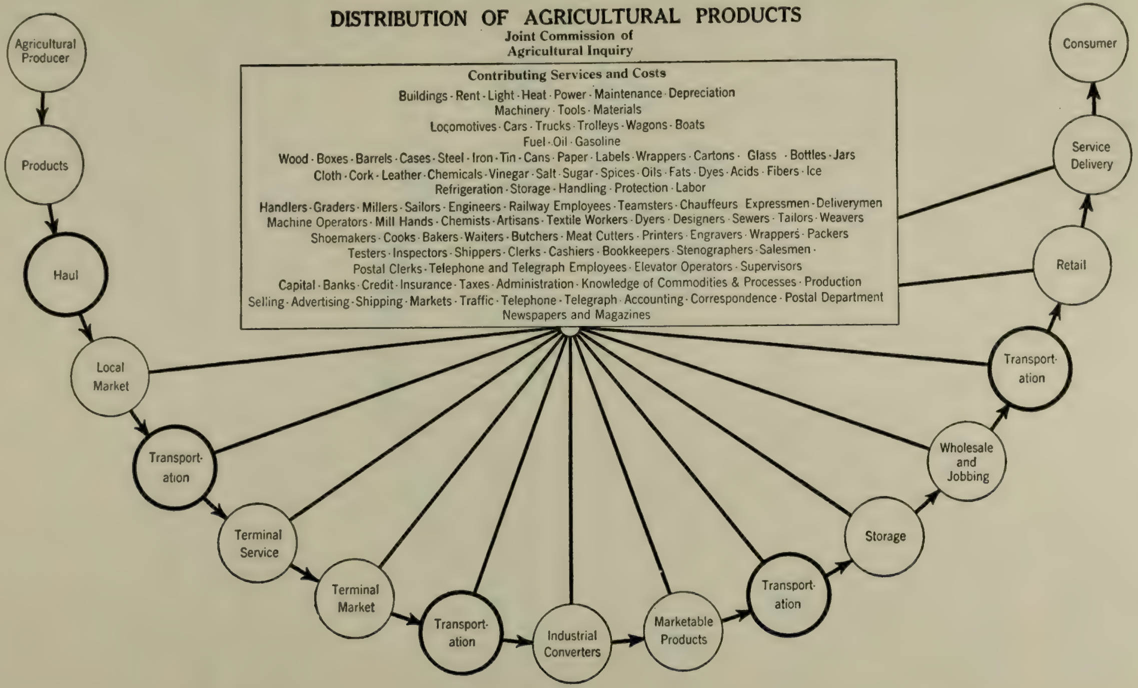
Original production of raw material
Haul
Local market
Transportation
Terminal market
Transportation
Industrial conversion of raw material into consumable commodities
Transportation
Storage, wholesaling, and jobbing
Transportation
Retail sale
Delivery
Final consumption in home of consumer

In the case of a manufactured commodity like a watch or an automobile, some of the earlier steps, as the haul to a local or terminal market, might be omitted, but there would be a great multiplication of transportation hauls between various stages in the conversion process, as between blast furnace and rolling mill, between rolling mill and finishing or machining establishment, between this and assembling plant, and still others.

The importance of transportation in modern life is even more striking. A century and a half ago a trip from New York to Philadelphia took three days; now it requires about two hours. A journey from the Atlantic seaboard to the region where Chicago or St. Louis is situated was a three months' pilgrimage; now it is a 24-hour run in a Pullman palace. The world can be compassed

DISTRIBUTION OF AGRICULTURAL PRODUCTS

Joint Commission of Agricultural Inquiry


Agricultural Producer
Products
Haul
Local Market
Transportation
Terminal Service
Terminal Market
Transportation
Industrial Converters
Marketable Products
Transportation
Storage
Wholesale and Jobbing
Transportation
Retail
Service Delivery
Consumer
Contributing Services and Costs
Buildings · Rent · Light · Heat · Power · Maintenance · Depreciation
Machinery · Tools · Materials
Locomotives · Cars · Trucks · Trolleys · Wagons · Boats
Fuel · Oil · Gasoline
Wood · Boxes · Barrels · Cases · Steel · Iron · Tin · Cans · Paper · Labels · Wrappers · Cartons · Glass · Bottles · Jars
Cloth · Cork · Leather · Chemicals · Vinegar · Salt · Sugar · Spices · Oils · Fats · Dyes · Acids · Fibers · Ice
Refrigeration · Storage · Handling · Protection · Labor
Handlers · Graders · Millers · Sailors · Engineers · Railway Employees · Teamsters · Chauffeurs Expressmen · Deliverymen
Machine Operators · Mill Hands · Chemists · Artisans · Textile Workers · Dyers · Designers · Sewers · Tailors · Weavers
Shoemakers · Cooks · Bakers · Waiters · Butchers · Meat Cutters · Printers · Engravers · Wrappers · Packers
Testers · Inspectors · Shippers · Clerks · Cashiers · Bookkeepers · Stenographers · Salesmen ·
Postal Clerks · Telephone and Telegraph Employees · Elevator Operators · Supervisors
Capital · Banks · Credit · Insurance · Taxes · Administration · Knowledge of Commodities & Processes · Production
Selling · Advertising · Shipping · Markets · Traffic · Telephone · Telegraph · Accounting · Correspondence · Postal Department
Newspapers and Magazines

to-day in less time than it took then to sail from New York to London.[1] Sixty-mile trains, 40-knot vessels, airplanes, telegraph, cable, and radio have combined to shrink the earth and to bring the most distant places into touch with one another.

The effect of improved transportation has been completely to alter our mode of life and our economic relations. A century and a half ago most of the people in this country raised their own food, made their own clothing, and fashioned their own tools and implements. To-day the descendants of one of these pioneers calls upon the whole world to provide the means for even a simple breakfast. He sits down to a table furnished with china from Germany and silverware from Great Britain, spreads out a napkin of Irish linen, opens his meal with a banana from Costa Rica, follows with a cereal grown in Iowa and manufactured in Michigan, sweetened with Cuban sugar and covered with cream from Wisconsin, and ends with a Montana lamb chop, a Maine potato, and a cup of Brazilian coffee. It has been estimated that the mileage of food transportation represented on the average American breakfast table east of the Appalachians is 14,000, while a full course dinner represents the circling of the globe.

State of Origin	Md.	Va.	N.C.	S.C.	Ga.	Fla.	Ind.	Ill.	Mich.	Wis.	Minn.	Ia.	Mo.	N. Dak.	S. Dak.	Nebr.	Kan.	Ky.	Ala.	Miss.	La.	Texas	Okla.	Ark.	Mont.	Wyo.	Colo.	Utah	Ida.	Wash.	Oreg.	Calif.	Total Car-loads 14,436 (includes 39 Carloads of Unknown Origin).
Carloads	13	532	130	66	3	160	3	97	562	5222	1865	4	267	470	515	238	1139	37	330	6	111	56	263	60	147	81	280	33	1538	21	101	47	

Where Chicago Obtained its Potatoes During the Year 1923

Potatoes from 32 states were shipped into Chicago; 18 of these States each shipped in excess of one hundred cars. The wide range of territory from which Chicago obtained its potatoes is illustrative of conditions in other large consuming centers.

Facilities for transportation. — The machinery of transportation includes the properties and equipment of steam and electric railroads, sleeping car companies, express companies, pipe lines, motor truck companies, aviation companies, ocean, lake, and river shipping lines, and drayage companies. In addition, there is much transportation done of which the hauling of wheat to market by the farmer is an example; transportation that is not an organized business. The properties and equipment of these different organizations include horses, wagons, trucks, freight stations, locomotives, freight cars, business offices, airplanes, landing fields, ships, docks, wharves, piers, roadbeds, switches, etc.

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[1] A record of 28 days was established in 1926 for the circumnavigation of the globe.

What constitutes good transportation facilities? — In the first place, transportation facilities, to be good, must be cheap, and the cheaper they are the more advantageous they are to the purchasers of goods. This is true not only because of the low rates, but also because it permits the location of industry in the most advantageous positions where costs of production are lowest. It also allows the concentration of industry in single establishments and the development of large scale methods of production, which further increase the efficiency of manufacturing.

Another requirement of good transportation is that it must be rapid. If the methods of moving goods are slow and there are many delays before they reach their destination, there may be serious losses because of spoiled products or changes in the price. Quick transportation means also a saving in interest. The desire of the shippers for fast transportation rather than lower cost slow transportation is evidenced by the fact that most of the meats and grain from the Chicago area move toward the Atlantic seaboard by rail rather than over the Great Lakes-New York Barge Canal-Hudson River water route.

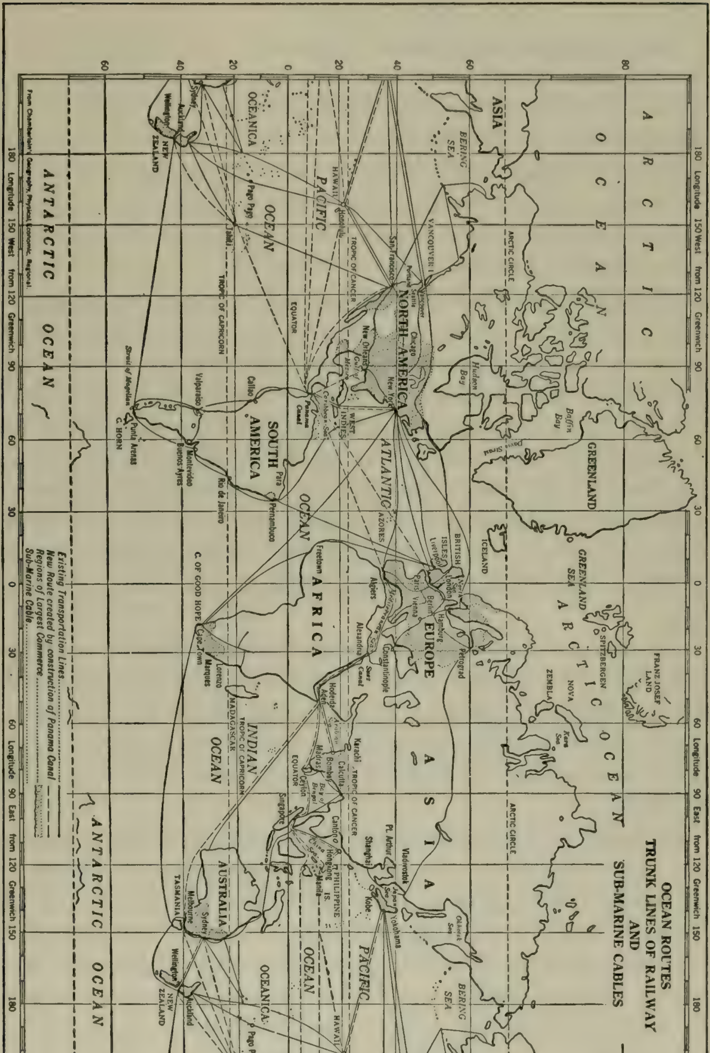
Transportation must also be dependable. Think of the trouble and confusion that would be caused if trains did not run on a regular schedule or if they could not be relied upon to operate at all times or without frequent delays. One problem in aviation is to obtain the proper conditions of weather when making a flight. Certain conditions make flying unsafe. Such circumstances make commercial aviation unreliable when it is necessary to have a passenger or cargo reach a destination at a certain time. Storms and wrecks are likely to impede any kind of transportation but in the case of land and water transportation, these difficulties have been reduced to a minimum. This type can be depended upon to carry out what it is scheduled to do.

The services of transportation. — Lines of transportation take goods from regions where there is a surplus to regions where there is a scarcity; from those places where they are not wanted to others where they are wanted. In other words, transportation equalizes demand and supply at a given price. It unifies a nation, or the whole world for that matter, commercially, and brings each section into relation with and dependence upon every other section. Perhaps one might appreciate the services of good transportation more if he were an inhabitant of certain parts of India, China, or Russia, where railroads are lacking, during a period of famine. Other sections of those countries may have food supplies, but they cannot be taken to the stricken areas except at exorbitant cost and then only in small quantities. The result is that people often starve by the thousands. This is a case where supply and demand cannot be equalized; the particular country is not unified within nor united with the outside world. Other regions may have large surpluses but they are of no avail to the ones who are starving.

It must not be concluded, though, that transportation is of importance only in connection with the marketing of finished products. That is only one phase of it. It is quite as important in obtaining supplies of raw material and fuel for the operation of our factories, and in transporting workers to and from the factories where they are employed. Transportation is thus as necessary to the operation of a factory as it is to the existence of groups of specialized workers. Were it not for good transportation the workers could not afford to become specialized.

Transportation and the localization of industry. — Transportation is one of the chief influences in determining the location of many industries. By this is meant the cost of transportation and not the distances which must be traversed. Distance is not an obstacle to the movement of goods except when coupled with high charges for carrying the goods. The movement of iron ore over the Great Lakes is an example. Practically all of the iron ore used in this country is transported about 1000 miles from the head of Lake Superior to the lower lake ports from which point much of it goes to Pittsburgh. There is iron ore near Pittsburgh but it is not used much because the low cost lake transportation permits the use of the better lake ores. If these Lake Superior ores had to move from the mines to the smelters by rail, they would be used to a much less extent than at present.

Transportation then allows industries to be localized and oper-



From Chamberlain's Geography, Physical, Economic, Regional

WORLD TRANSPORTATION ROUTES

ated most advantageously and in the end gives us cheaper products than could be produced otherwise.

Transportation and efficient production. — By having its industries located in the most advantageous position, a country obtains the advantages claimed under the doctrine of comparative costs. This doctrine is in substance that every region should produce only those things which it can do with the greatest comparative advantage and procure the other goods that it needs from regions which have similar advantages in their production. An illustration will serve to make this clear.

Minnesota and Pennsylvania can both produce wheat and steel. But why does not Pennsylvania grow all of the wheat needed by her workers, and Minnesota produce all of the steel needed by her industries? Only because each state will have more in the end if it puts its efforts into the production of the thing for which it is best suited. Pennsylvania has better prerequisites for the manufacture of steel and Minnesota for the growing of wheat. So it is cheaper for Minnesota to concentrate upon wheat production and buy her steel from Pennsylvania, and for Pennsylvania to buy her wheat from Minnesota with the products of her steel mills.

The same is true of every region. One is suited to one product and another to a different one. Each will produce a greater total product and have the greater gain in the end if it will confine its efforts to those things for which it is best adapted. But this involves a great deal of transportation of goods from one point to another.

Demands of modern industry upon transportation. — Since the oceans were first crossed and the first railroads were built industry has continually called for more and better transportation. These demands have caused transportation companies to seek continually for methods by which they might give better and cheaper service. The equipment has steadily been enlarged and improved, permitting a smaller hauling charge per unit because of the larger loads that can be hauled by a single locomotive. Special processes have been employed such as the use of refrigerator cars in hauling perishable products and the recently invented refrigerator tank car for transporting fresh milk over long distances. Recently locomotives have been improved so that they will get a great deal more power from a given amount of coal than formerly. These and numerous other improvements have had the effect of increasing the efficiency of our railroad facilities.

These changes have been necessitated by the growing population and markets, and the increasing extent to which industry is being localized and specialized. When scarcely any one is self-sufficing the volume of goods to be moved is large, and the less self-sufficing a group of people becomes, the larger is the proportion of commodities that must be transported. It is sometimes difficult to tell which is cause and which is effect in the relations and intertwinings of transportation and the specialization and localization of industry. Transportation makes those developments possible but they in turn make greater demands upon the transportation facilities. The two go hand in hand.

Facilities for communication. — The work of the facilities for communication is to transmit information from one place to another just as the facilities for transportation transport people and commodities from region to region; indeed one method of communication, namely the post office, utilizes the various means of transportation to make it effective. In turn, the telegraph, telephone, cable, and radio companies are necessary for the operation of our transportation systems.

The facilities for transmitting ideas, in addition to the postal department and systems of transportation, are the plant and equipment of telephone and telegraph companies, wireless telephone and radio companies, and cable companies. In addition, the services of a great many people are required to collect and digest this information, and to make it available to the interested public.

The services of communication. — In general, the services of communication are similar to those of transportation but are more pronounced in their effects. Communication annihilates distances and makes the world one compact economic and social organization. Information from almost any part of the earth can be obtained within a very short lapse of time. The industrial world is kept well informed of everything that is taking place within it. Communication is thus the means of coördinating the actions of all the different groups. It brings them into the proper relations with one another. A unity, a self-consciousness, and a stabilization, not otherwise possible, are obtained.

The actual work done is to give information of any nature that will affect people socially, politically, or economically. We are not interested in the former two here except in so far as they affect the latter. Regarding it, communication makes known the existing conditions of demand and supply and any conditions that are likely to affect their relationship. Other information relates to prices and their changes, the volume of sales and purchases, the condition of the gold reserves and banking, and every other sort of information that is needed by business.

Evidences of these services. — Pick up a morning daily paper and you will see price quotations of all sorts. These change from day to day, and the changes are brought about quickly because of rapid, almost instantaneous, communication. There are, in addition, numerous items concerning the condition of different industries in various locations. The financial situation, the position of the gold reserve in every country is made known. Reports of the ambassadors and consuls to foreign countries are filled with such information. Different industries publish trade papers; produce exchanges and Chambers of Commerce disseminate information. The different departments of the national government, especially the Departments of Commerce and of Agriculture, are continually sending out information in their respective fields, and even have it broadcast by radio in order that it may be of the most value to those affected. This does not exhaust the list of such services, but is sufficient to show their wide use and extent.

SUGGESTIVE QUESTIONS

1. Read the advertisements in your local paper and tell how many of the products advertised came from distant points.
2. Look at the fruit in a typical fruit or grocery store and estimate from what countries the products came, and how long were the distances over which they were transported.
3. Estimate through how many different markets such articles as your note book or pencil, the classroom seats, or other similar things, have gone before they reach the ultimate consumer.
4. Exactly what is done in a market?
5. Is the work of the retailer productive? Of the wholesaler? Of the broker?
6. Illustrate concretely the number of transportation hauls in the life history of some one article from its origin as a raw material to its final consumption as a finished good.
7. Calculate the amount of transportation involved in your own breakfast or other meal.

8. Can you name any other transportation agencies, in addition to those enumerated in the text?

9. Three qualities of good transportation are described in the text. Can you name any others? Which of the three described seemed to you the most important?

10. During the Middle Ages famines were of frequent occurrence in Europe; to-day they are unknown. How do you account for both these facts?

11. If the Great Lakes should dry up, what would probably become of the iron and steel plants in South Chicago, Gary, Cleveland, and other Lake ports?

12. Is there a waste involved in the transportation of fruit from California to Massachusetts in exchange for shoes produced in the latter state? Would there be a saving if each state produced its own fruit and shoes, and distant transportation were eliminated?

13. In what ways would commercial aviation be better than rail transportation?

14. Explain the value to modern industry of the market reports in the daily paper.

15. Ask a local merchant if he makes use of any of the information furnished by the government departments, local associations, or trade journals.

BIBLIOGRAPHICAL NOTE

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CHAPTER XXXVII

MONEY AND CREDIT

Modern industry based on exchange. — A pioneer colonial farmer was nearly self-supporting; he produced almost everything which he needed, and on the other hand he consumed practically everything he produced. He had little to exchange and had very slight need of money. In modern industry, however, most goods are produced for sale on a market rather than for immediate consumption. Exchange is a necessity for a society of specialists, each of whom concentrates upon the production of some one article, or part of an article, and exchanges that for the products made by other specialists.

The necessity for exchange arises from the differences between geographic regions and differences between individuals. Mineral deposits are unevenly distributed throughout the world; climatic conditions confine certain products like cotton, rubber, bananas, coffee, corn, etc., to definite regions. If the advantages of these favored localities are to be shared with the inhabitants of other regions, exchange must take place among them. This is territorial specialization. Even more important in modern industry is individual specialization, according to which each individual concentrates upon the production of some one thing for which he is best fitted, whether by natural bent or by training. Division of labor also calls for exchange.

Economists recognize three historical stages in the gradual development of exchange, which are called exchange by barter, by money, and by credit.

Exchange by barter. — In a primitive society exchange is carried on by the direct trading or barter of one good for another. Among the North American Indians, by whom money was unknown, there was a wide distribution of such articles as copper ornaments from the Lake Superior region, of cowrie shells from the Atlantic coast, and of other things from particular regions, which was affected by a system of exchange of gifts or barter. Early traders to the African coast carried on their transactions entirely by the barter of European manufactures for gold dust, ivory, palm oil, gum, and other raw products. Even to-day there are belated cases of barter in the trading of agricultural products for store goods at the country store, or in the partial payment of wages by board and lodging or goods. The myriad transactions of modern industrial society could not, however, be carried on under a system of direct barter. Three main difficulties are usually cited.

The first difficulty would be to find two persons whose disposable possessions mutually suit each other's wants. There must be a double coincidence of wants and possessions. A person having some potatoes and needing a pair of shoes must find another person who has a pair of shoes to dispose of and wants potatoes. And even if by rare chance these two persons should come together, it is not certain that the different articles would be of such size, quality, or quantity that a direct trade could be agreed upon. This suggests a second difficulty in barter. At what rate is any exchange to be made? How many potatoes shall be given for a pair of shoes? Or how many of either of these for a football ticket? Among 100 articles there are 4,950 possible ratios of exchange. Evidently the myriad exchanges of modern life could not be carried on with such a complicated price list. A third difficulty in barter arises from the difficulty of dividing many kinds of goods. A bag of potatoes might be portioned out, but a pair of shoes could not be separated and much less subdivided without having their value entirely destroyed.

Exchange by money. — These embarrassments in direct barter are obviated by the introduction of a third term, which intervenes between the two articles to be bartered. If traders will agree upon some common commodity which they are all willing to receive, say money, then the owner of the potatoes will dispose of them for so many units of this money with the full assurance that the owner of the pair of shoes will be willing to part with them for a definite number of money units. This common commodity, money, is called a *medium of exchange* because it acts as an intermediate term in all acts of commerce.

The use of money also solves the second difficulty in barter, for the introduction of an intermediate term makes it possible to determine the ratio of exchange of every commodity with this one unit instead of with each other. If it is known how many units of money will exchange for a bag of potatoes, and also how many units will exchange for a pair of shoes, it is not difficult to determine how many potatoes must be given for the shoes. In this case the money is said to serve as a common denominator or *common measure of value,* in terms of which we measure the value of all other goods, so that they become easily comparable.

The third inconvenience in barter is also met by the introduction of money, for by the use of coins of various kinds and sizes the money unit can be divided and subdivided into as small fractional units as desirable, so as to meet varying requirements.

Services of money. — Of the functions of money just described its use as a medium of exchange is the most familiar. The family income is probably received in the form of a weekly or monthly sum of money. This in turn is exchanged for housing accommodations, food, clothing, recreations, doctors' services, and a multitude of other things. The money, to be sure, is merely a medium in the exchange of the products or services of one individual against those of another; barter has been broken up into two stages by the introduction of an intermediate term. From this standpoint money is merely a counter; it performs its service when it is passed on. And yet modern commerce would be inconceivable and impossible without this service of money, just as it would be impossible without transportation agencies.

The second service described above — that of acting as a common measure of value — is equally important. Without some sort of measuring stick it would be impossible to compare the relative importance of such diverse things as potatoes, shoes, football tickets, cigarettes, doctors' services, house rent. But by assigning a price to each of these things it is possible to compare them in terms of the single money unit. If a pair of shoes costs six of these counters or units and a football ticket costs three, then we say that a pair of shoes is worth two football tickets. By the use of such a measuring stick or unit it is also possible to determine whether society as a whole places a higher value upon one sort of goods or service than another; upon the basis of such a comparison the apportionment of the human and material resources in the work of production takes place. If consumers are willing to give twice as many money units for an automobile as for a piano, whose cost of production is the same, then more automobiles and fewer pianos will be produced.

Modern industry, as has been said before, produces goods for sale in the market; what and how much shall be produced depends upon price, stated in terms of this money unit. Money therefore is the very focus and center of modern business activity. Americans particularly have been accused of being mercenary and of measuring all values by a money standard. While it is true that some things, like friendship and health and culture, cannot be bought, yet the things which money will buy may make these easier of attainment. At the very heart of modern industry and business stands money.

Exchange by credit. — Only a small proportion of the transactions of the modern business world — probably not over 15 per cent — is carried on by cash payments of money. Most of them are credit transactions. "When a housewife orders groceries and has them charged on the books of the grocer, the purchase is a credit purchase. When a merchant buys goods and gives as payment his note due in sixty or ninety days, he is said to buy goods on credit. When a farmer borrows money for improving his farm and gives his note for the money received together with a mortgage on the land, he is said to secure money through credit. When a railway sells its bonds and with the proceeds of the bonds constructs a right of way and buys locomotives, the sale of such bonds is a credit transaction."[1] In none of these transactions is money used, but instead a charge on the books of a grocer, a note, a bond, which are promises to pay money in the future, are used. A credit transaction is one in which futurity of payment is involved, as well as faith in the person or corporation which gives its promise.

Although money is not used in credit transactions, these are always expressed in terms of the money unit. The money promised now will be actually paid when the credit terminates. When used for this purpose money is said to serve as a *standard of deferred payments*. Practically all wage agreements, house rentals, contracts, sales for future delivery, life insurance, and other transactions whose fulfillment lies in the future, are credit transactions which are expressed in terms of money and rest on money as a standard of deferred payments. Through credit, money lays hold of even the distant future. As society has progressed from isolated production to our present complex industrial society, it has passed from the stage of barter to that of money, and now is moving over to a credit economy. Credit has not only greatly increased and quickened the usefulness of money, but itself makes possible the transaction of business on a vastly greater scale than would be possible by the use of either barter or actual money.

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[1] H. C. Adams, *Description of Industry* (New York, 1918), p. 180.

Credit instruments. — Just as exchange by money requires the use of a money unit, so exchange by credit necessitates the use of various documents known as credit instruments. The merchant, whose customers " charge " their purchases, keeps a set of books in which a record of these transactions is made; this is called book credit. When an individual borrows money of another individual or of a bank to be repaid in the future, he generally gives a promissory note — an I.O.U.; this reads somewhat as follows: " One year after date I promise to pay to John Doe $1,000. (Signed) Richard Roe." If a government or a corporation wishes to obtain money with which to wage war or build a railroad or expand its plant it usually issues bonds, which are simply promises to repay the sums borrowed at a specified date in the future; the rate of interest, date of maturity, and other matters are set forth in great detail in the bond.

The most used credit instrument is the personal check, which is the common form of payment for the larger daily transactions, payment of bills, dividends, interest, rent, and other items. A check is an order by one person to a bank, directing it to pay a specified sum of money to another person named in the check.

In all these cases papers or documents or orders are used as media of exchange instead of money. In cities and in the wholesale trade probably 95 per cent of the transactions are carried on by the use of credit instruments of one sort or another; and even in retail trade over 60 per cent are thus conducted. Credit instruments have thus largely superseded the use of actual money, but they are always stated in terms of money units and rest upon money for their final satisfaction. These instruments are however merely evidences of the credit transactions which have already taken place; they are the tangible things which one sees, but credit is intangible: it is an act of trust or confidence to be fulfilled in the future. The importance of credit is indicated by such statements as " credit is the life-blood of commerce."

Credit institutions. — The development of credit and the general substitution of credit instruments for money have led to the growth of a number of institutions whose business it is to furnish credit. Of these the most important are banks. A bank has been defined by one writer as " a manufactory of credit and a machine of exchange," and this definition emphasizes its two most important functions. It will not be possible here to explain the nature and operations of banking, but its main purpose is to provide credit to be used by the industrial and business world to carry on the productive processes. Some of this credit will be needed for a long period of time and this must be provided by investment banks and bond houses, by savings banks, and by building and loan associations; other credit for a short period, perhaps not over ninety days, is provided by commercial banks.

In order to explain the nature of the credit transactions involved in the granting of both long and short term loans, an illustration may be taken from the financing of the manufacture and sale of cotton fabrics. This may be divided into five stages: (1) the construction and equipping of the factory; (2) the manufacture of the cotton fabrics; (3) the sale of the fabrics to wholesalers; (4) sale by the wholesaler to the retailer; and (5) sale by the retailer to the final consumer.

Long term loans for the construction of the factory. — It is seldom that the enterpriser, proposing to undertake so large an undertaking as the building and equipping of a factory, has sufficient funds of his own; he is compelled to borrow a portion of them. A site must be purchased; the material and labor for constructing the plant, and equipment for operating it, must all be bought. The funds thus expended must be employed for several years before they will earn a sufficient return to repay the outlay. Credit for a long period is needed and this may be obtained in the form of a long term loan. To obtain this the enterpriser will seek the services of an investment banker, who will advise as to the best method of obtaining the loan and will probably undertake to raise it. To do this he will probably suggest the flotation of a bond issue with the property of the concern as security. A mortgage will be placed upon the property, and this mortgage, which is a claim against the property in case the promises contained in the bond are not fulfilled, will be deposited with some agent as security for the bonds which are to be sold. The investment banker may either buy the bonds outright from the cotton manufacturer or handle them upon a commission basis, but in either case he will sell them to others.

The buyers of these securities are individuals, commercial and savings banks, trust companies, insurance companies, and any other organizations that may have surplus funds to invest. The above named financial institutions have collected the surplus funds of numerous individuals and they now further the productive processes by loaning a part of them to the cotton manufacturer. The investment banker has brought the borrower and lender together. He has been instrumental in placing the small savings of many different people in a productive enterprise, and the borrower and lender as well as all society gain thereby.

Short term loans to finance manufacturing. — After the plant is ready for manufacturing operations to begin, raw materials, fuel, labor, and similar things are needed. Again credit will be required to pay for these things, as it will be a little while before any returns will be received from the sale of cotton fabrics. This intervening period may be tided over if the manufacturer can obtain a short term loan, for 30, 60, or 90 days. It would be inadvisable to issue bonds for this purpose, so resort is had to a commercial bank, which specializes in this form of credit. If the bank is satisfied with the character of the borrower, the organization and management of the factory, and similar matters, it will lend the manufacturer a reasonable amount, taking in return his promissory note payable in say 60 days. When the sale of the cotton fabrics begins to bring in returns to the manufacturer he can pay off his credit at the bank and receive back his note.

In the further course of manufacturing operations the manufacturer will probably ask for credit frequently at the bank, the amount and term of the loans varying with the rapidity of turnover of his stock and the profitableness of the business. The commercial bank is able to extend this credit because it enjoys the confidence of the whole community; it has at its disposal idle funds with which depositors have temporarily entrusted it and it also lends its own credit. By lending these to the cotton manufacturer the bank has aided a productive enterprise and benefited the whole community.

Marketing the cotton fabrics. — This comprises the last three steps mentioned above, but since they are all concerned with the marketing of the finished product they may be discussed together. The manufacturer first sells to a jobber or wholesaler. Like the manufacturer, the wholesaler may not wish to keep his funds locked up and idle for the purpose of holding the goods until he can sell them to the retailer. So he goes to his banker and borrows what he has already disbursed, using the goods perhaps as security.

The retailer is in the same situation. He must buy a stock of goods and keep them on his shelves until the consumers want them. It is, therefore, economical for him to borrow rather than use all of his own funds for this purpose because he can employ this money to better advantage by enlarging his business.

Finally, the goods go into the hands of the consumer. But he may not have any funds when he needs to buy the goods. He will therefore borrow from his banker, or else have a charge account with the retailer and let the retailer borrow from the banker with the charge account as security.

What the banker does. — We thus see that throughout all of the stages of the productive process the banker is an ever present and necessary figure. Were it not for him, business could not assume its present proportions nor would it likely be so safe. Because he is dealing in other people's funds and must therefore keep them safe and subject to demand by the depositors, the banker must be very conservative in the granting of loans, extending them to only the most capable and honest men and to the most deserving enterprises. He is thus a sort of industrial policeman or watchdog. He can often prevent the entry of dishonest men into business because he cannot make loans where there is any likelihood of loss from dishonesty. Likewise he can prevent the use of funds in uncertain enterprises. He may be said to drive the automobile of business; controlling its accelerator and also its brakes. While this represents the ideal, the banker is unfortunately not always a steadying influence. Since his profits depend upon keeping his funds actively employed, he is sometimes tempted to grant credit to doubtful enterprises. He steps on the accelerator when he should have his foot on the brake. Such a mistake may wreck a bank as well as an automobile.

The banker's most important service to production, then, is the granting and control of credit based upon the accumulated savings of numerous individuals and organizations. He takes dormant wealth, personal ability, and honesty, capitalizes these by using them as security for the granting of loans, and thus facilitates the production of goods. Industry is expanded and the consumers have more and cheaper products because of his services.

Bankers also provide instruments for the exchange of goods in the form of checks, drafts, notes, letters of credit, etc. This greatly facilitates the process of exchange because it makes unnecessary the shipping of so much money and currency to the various sections of the country. Each section of the country buys from and sells to every other section. Instead of sending cash to settle these transactions the banks transfer credit by means of drafts — which are checks drawn by one bank upon another — letters of credit, or perhaps telegraphic transfer. These transactions tend to offset each other, and only a small amount of actual money is needed to settle the balance. Business transactions involving the movement of funds are thus made easier and safer.

Bankers also encourage thrift. People are encouraged through the payment of interest to deposit their funds with the banks. This gives every person a part in furthering production because these funds are made available to business and industry.

SUGGESTIVE QUESTIONS

1. How many things, consumed in your family during the past year, were produced within the home?

2. Sometimes children trade toys or books or other personal possessions with each other. Do they apply any common measure to determine the terms of the exchange?

3. Try to find illustrations of barter with the natives in books written by travelers or explorers in Africa, Asia, or the Americas.

4. Name some things, other than metallic or paper money, which have served as a medium of exchange at one time or another in different parts of the world.

5. The common measure of value, upon which the major industrial nations have agreed, is gold. Why has this metal been selected?

6. " If consumers are willing to give twice as many money units for an automobile as for a piano, whose cost of production is the same, then more automobiles and fewer pianos will be produced." Using this illustration, show how price will determine the social apportionment of land, labor, and capital to different industries.

7. " Every man has his price." Explain and criticize this statement.

8. Ask your father to estimate the proportion of his monthly expenditures which he pays by check and which he pays by money.

9. What attribute is especially desirable for money which is to serve as a standard of deferred payments?

10. Define in your own words: credit; credit instruments; credit institution.

11. Bring a blank check to class and explain just what it is. What is the difference between a check and a draft?

12. Do you think it is a good thing for a man to go into debt in order to start an industry or a business?

13. Would it be possible for a young man, without any capital of his own, to borrow money from a bank in order to start in business on his own account? What security would the bank have that the loan would be repaid? Is this good banking?

14. Do you think the banker performs a useful service? A necessary service?

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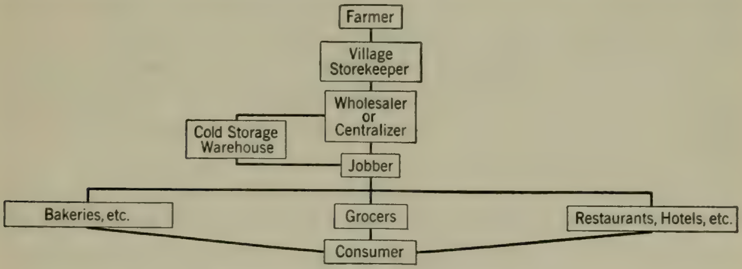
CHAPTER XXXVIII

THE MIDDLEMAN

Kinds of economic production. — The two previous chapters have emphasized the importance of transportation and money, — the former as a physically connecting link between the different stages in production or between different regions and industries, the latter as an agent in facilitating the work of exchange. But equally important are the services of another group of specialists who assist in the marketing of commodities as they pass from one group of producers to another. These are middlemen, called so because they stand between the primary producer and the consumer. The name is somewhat unfortunate, because it suggests that they interrupt the process of production, whereas they really carry on the work which has been already begun.

A distinction is often made between the manufacturer and the merchant, and the former is said to be productive while the latter is not. The manufacturer changes the form and combination of raw materials and produces a finished good. Here is a very obvious and useful service to society and no one begrudges the manufacturer his profits. What does the merchant do? He buys commodities where they are produced and sells them where they are wanted, and when he asks to be paid for this service he is called " robber " or " parasite." We must pause here a moment and ask the question, what is production? To produce a good is to give it *utility* so as to make it serve human needs and gratify human wants. But an article may have *form* utility, as when a chair is fashioned from a standing tree; or it may have *place* utility, as when it is transported from the factory to the retail store to be sold; or it may have *time* utility, as when it is kept until the moment when the consumer wishes it. Now it is clear that the work of the average manufacturer stops with the giving of form utility to his products; at that point the middleman merchant steps in and carries the products through further steps in the productive process, which finally places the finished commodity in the hands of the consumer just where he wants it, just when he wants it, and in just the right amount. This is truly economic production, that is the creation of utilities.

Linking up the stages of production. — We may think of production as divided into a series of stages; of which the production of bread may be taken as an illustration. If we go back far enough in the life history of bread we get to the farmer raising wheat; that is a process complete in itself — the first stage. The second stage, let us say, is that of grinding the wheat into flour (though there are others which are omitted for the sake of simplicity); but the thousands of individual farmers do not know the millers and the miller would not bother to buy in small lots from the farmers, so a commission agent or grain elevator company buys the scattered wheat from the farmers, grades it, and sells it to the millers. When the miller has finished his task he has a supply of sacked or barrelled flour for sale, but since he has specialized in the milling business, he has neither knowledge nor facilities to market his flour. At this stage another group of middlemen — jobbers, brokers, etc., — who have specialized in this work, step in and manage the sale of the flour to the wholesaler or to the baker. The work of baking the bread is a specialized occupation, and the work of distributing the baked loaves to the consumers is again intrusted to middlemen.



Middlemen in Egg Production

Between the farmer's poultry farm and the final consumer of the eggs stand various specialized services in the process of marketing.

Functions of the middleman. — In the operations just described the middleman performs functions of undoubted value both to producers and to consumers. In the first place he provides a market for the specialized producers earlier in the series and sells to those farther along. He organizes the demand for the various products on the market and brings it in touch with the producer, who is himself without the time or the knowledge or the facilities for disposing of his wares. He also equalizes supply and demand. Many commodities, especially agricultural products, come on the market in fluctuating quantities, unevenly spread throughout the year; and demand also varies according to the season and other factors. It is the function of the middleman to gather the supplies together, hold them until needed, and direct them into channels where for the moment demand is greatest. A sort of clearing house is thus established.

Such services are of value not merely to the producer, but also to the consumer. In an earlier chapter it was pointed out that supplies for even the breakfast table are drawn from long distances. But the modern consumer could not purchase directly from the sources of supply. The energies of a separate group of specialists are needed to scour the world for products, to bring them to the market, and to hold them at the disposal of the consumer until wanted.

It would be possible to eliminate these middlemen, that is, in the illustration, page 563, for the farmer to sell his wheat directly to the miller and for the miller to sell his flour to the baker, but in so doing the *function* of the middleman would not have been eliminated. It is simply a question whether it is more economical to let a specialist do this work and be paid for it, or for the farmer and the miller and the baker to do it for themselves. In either case the work will have to be done and paid for: either in a cash return to the middleman or in expenditure of time and effort by the farmer and miller and baker which they could probably use more profitably in their regular business. In every large department store buyers are employed who go to the great wholesale markets and purchase merchandise for their establishment; but the smaller stores, which cannot afford to employ their own specialists, obtain their stocks from jobbers, who are specialists in the employ of the public. The function of the large store's buyers and of the jobber is identical, though only in the second case do we speak of him as a middleman.

The technical functions of the middleman. — In addition to the general functions just described, the middleman performs very definite services in the physical handling of the goods. These have been classified as follows: [1]

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[1] Converse, P. D., "Some Notes on Marketing Functions," in *Journal of Political Economy,* 34: 382. June, 1926.

"Buying (including assembling), storing, risk bearing, financing, standardizing and grading, selling, transporting, packing (as distinguished from packaging), and dividing."

Few of these activities were called for in a primitive, self-sufficing economy, but in our modern industrial world, based upon specialization and sale of goods in the market, it is difficult to see how any one of them could be dispensed with.

Buying. — Buying comprises the discovery of supplies, their purchase, and their assembly or concentration at a desired place. The marketing of wheat will serve an illustration. Local country elevators purchase and assemble in one lot the wheat produced by the different farmers of a given locality. Several of these country elevators ship their wheat to a single large terminal elevator in one of the large grain markets, which, in turn, sells it to flour mills, breakfast food concerns, and exporters. Those who utilize wheat need it in large amounts. They cannot afford to go among the farmers and buy a few hundred bushels here and a few hundred there. Neither can the farmer, with his small quantity, afford to ship it to a large terminal market or endeavor to seek out those who will use it. Thus we have our complex grain marketing organization, in which the specialized middleman has his place.

Facilities for storage. — Storage consists in putting commodities in a place of safe-keeping until such time as the market or the consumer can use them. The facilities for doing this consist of cold-storage plants; grain elevators; warehouses, both private and public; granaries and cribs on the farms; underground caverns and bins; and large outdoor yards for surplus stocks of products that can withstand the elements.

There are two types of storage: cold and dry. The former is used for products that are perishable within a short time such as meats, fresh fruits and vegetables, eggs, and butter. Cold storage may be in a building that is kept furnished with ice or in a place kept cool by artificial or mechanical refrigeration. Dry storage is simply placing products which will not spoil in a place where they will be protected from the weather. Wool, cotton, tobacco, wheat, and coal are examples.

Storage, by making possible the saving of surplus production and the carrying of it over from one season to another, helps to equalize demand and supply. But unlike transportation, which equalizes supply and demand from the standpoint of place, storage equalizes them from the standpoint of time. This helps to stabilize prices and to maintain greater uniformity of prices throughout the year. This is of vast benefit to industry.

Storage also prevents a great waste by taking surplus products, that otherwise might not find a profitable market, and keeping them until they can be sold to advantage. It is an aid to orderly marketing. Thus is a great problem removed from the shoulders of the primary producers, especially in the case of perishable commodities.

With cold storage, consumers are able to obtain many products out of their natural season, and in a few cases those that might otherwise not be obtained at all. The ability to purchase in the interior of the United States ocean fish that are practically fresh is an example of the latter.

In another way storage is a benefit to production. If a person has products stored in a reputable warehouse, he can take the warehouse receipt, which he receives when the goods are deposited there, and borrow money at the bank with the receipt as security for the loan, and use the proceeds in the further production of goods. Dormant capital is thus made liquid and used as an aid to the production of still more goods.

Storage is thus seen to be a great help to the economical and efficient production and utilization of goods. It conserves what otherwise might be wasted until a time when it will bring a profitable price; keeps goods until the consumers need them; extends the marketing area for some products; gives confidence and stability to industry by maintaining fairly uniform prices; and makes possible the use of stored products in furthering the productive processes.

Risk-bearing. — The production of goods by groups of specialists is attended by considerable uncertainty and risk. There is the chance that the goods, which have been made in anticipation of an expected demand, may not be sold for enough to pay their costs by reason of a change in demand. They may be sold so slowly that deterioration and spoilage occur. In the case of agricultural products the accidents of weather may bring about too large or too small a yield and thus adversely affect the returns. The very organization of modern industry and business involves a certain amount of insecurity.

Since uncertainty is generally regarded as an evil, various devices have been developed to lessen it or to mitigate its effects. Farmers and shippers are advised by the government weather bureau as to the probable storms, frosts, and similar mischances. Similarly business barometers are being increasingly studied, and forecasts of economic storms or fair weather are made for the benefit of the manufacturer or merchant. Better methods of construction and equipment have reduced the dangers from explosion, shipwreck, fire, and similar losses. The absolutely unavoidable risks are met by insurance; this does not eliminate loss, but it spreads it out more evenly over society as a whole by consolidating or pooling the risks. The loss of one is met by the small payments of premiums by many others.

Among the various groups of specialized middlemen there has developed a class of persons who are ready to assume the risks of modern industry. These are generally termed speculators, for they deal in future contracts. They sell to a miller wheat to be delivered in three months; to a contractor materials needed in six weeks hence. Or they agree with a manufacturer of cotton fabrics or of steel rails to purchase his output during the next month at a definite price. The speculator or middleman thus assumes all the risks of price changes, and the miller, the contractor, and the manufacturer can devote themselves solely to their own specialties. If the function of risk-bearing is intelligently and successfully performed by a trained and well-informed group of experts, industry will proceed more smoothly and society will be a gainer.

Financing and transporting. — Institutions like railroads, banks, and insurance companies are generally called " functional middlemen," because they do not stand directly between producer and consumer of any one article, but rather stand to one side where they serve all other specialized units in business or industry. Their work does not involve the physical handling of goods, as does that of other technical middlemen. They are of such importance that they have already been treated separately in previous chapters.

Standardizing and grading. — " Standardization refers to the drawing up of rules as to quality, size, etc., while grading refers to the actual work in accordance with these rules." [2] The marketing of eggs may be used as an example. There are different market classifications of eggs based upon size, color, cleanliness, and age. These are the standards in accordance with which the trade does business. The grading consists in sorting them into large ones and small ones, brown ones and white ones, clean ones and dirty ones, and removing the spoiled ones, which must be done by candling. An egg that has started to germinate is not marketable at all. Among the coöperative marketing associations of Denmark this work is done very carefully and systematically. The date of the marketing and the number of the association is stamped on the egg and if a farmer brings bad eggs to market three different times, he loses his membership in the association.

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[2] As above, p. 380.

What are the benefits derived from these functions? In the first place, the consumer can obtain the exact product desired and is not in danger of having some unscrupulous or unknown dealer foist some inferior product upon him. The producer is forced to use care in preparing his product for the market. This means better products and less work and expense for all those who must handle the products after they leave the hands of the primary producer.

For the producer it may, and no doubt does in many cases, mean greater returns. The producer of each different grade is paid accordingly. If all grades were sold together, the good products would suffer by being mingled with the poor ones. This would tend to discourage the production of the better grades. But if the better products sell for a higher price, it encourages their production. This is one way, then, of encouraging the production of goods of a superior quality.

There are countless devices for grading commodities. There are screens for sorting coal, potatoes, and fruits into their various sizes; and for separating the undersized and inferior grains of cereals from the better ones. Recently, a machine has been invented that will, without human aid, detect thirty-nine different shades of color in tobacco leaves; also one that will remove the dust from apples as they pass through it.

Selling. — Selling includes all of the work done by a local merchant, for example, in getting the goods into the hands of the consumer after he once has them in stock. In short, it involves the awakening of a demand on the part of the consumer and the placing of the goods desired in his possession. The tools of selling are salesmanship and advertising, both in publications and by displaying the product. These methods are often attacked on the grounds of being wasteful and adding unnecessarily to the price of the products sold. It is claimed that high powered salesmanship and advertising induce people to buy products that they would not have bought otherwise; and to buy products which, often, they cannot afford. These criticisms may be true in some cases but hardly in all. In leading to a greater volume of sales, they might pay for themselves and not add anything to the price. They might even lead to such a volume of sales that the unit selling price could be reduced. We may conclude, however, that if people buy things because of these influences which they would not have bought otherwise, they are merely lessening their ability to buy other goods or are shifting their demand from one brand to another of the same product.

Examples of Packaging

Packing. — Packaging means "placing goods in containers in which they are to be sold to the ultimate consumer — and packing, the wrapping and crating necessary for delivery. The first would then be considered as a part of production and the latter as a part of marketing."[3] A box of Grapenuts which you buy has been packaged, but a peck of potatoes or a pound of apples has been packed. A manufacturer or primary producer must generally crate or box his goods before they can be shipped, and the volume of the shipments often makes it necessary to put them in large containers. But the retailer must sell in small amounts. It is therefore necessary for him to break up the large packages which he receives and put the goods in other and smaller containers before he is able to deliver them to the consumer.

Goods are packaged both as a necessary prerequisite for their transportation and to extend their sale. One may obtain half-pint, pint, and quart bottles of milk. A half-pint bottle makes a glassful to be drunk at a meal. Breakfast foods are now put up in containers of a size that will hold enough to make a single meal. Such measures are a convenience to the consumer and increase the demand for the products thus packaged.

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[3] As above, p. 382.

Dividing. — Dividing refers to the breaking up and rearrangement of shipments of goods into sizes of lots which the consumer desires. Sometimes grading is also done when goods are divided. This process increases the salability of goods by making it possible for the consumer to buy without delay the exact amount that is needed.

Can the middleman be eliminated? — In spite of the many and real services performed by the middlemen there is a growing belief that there are too many of these specialists and that it should be possible to reduce the number of the persons engaged in marketing. Farmers have been dissatisfied with the price which they receive for their wheat. Consequently, they are organizing farmers' cooperative elevators and in some instances maintain their own receiving and selling organizations at the large central markets. In so doing they have not eliminated any functions. Just as many steps are required to get the wheat to the consumer of wheat products as formerly, but the farmers are themselves doing many of the things which were formerly done by others. The whole advantage now goes to the farmer. He increases his profits by receiving that which formerly went to other groups, but he does this because he has invested additional capital or because he gives more time to the marketing function and receives pay for these services. If, however, he does this work less efficiently, or neglects in consequence the work of farming, he will suffer a loss.

In the field of manufacturing the number of middlemen is also diminishing. Manufacturers, especially those manufacturing upon a large scale, find it profitable both to buy their raw material directly from the producer and to sell the finished product direct to the retailer or consumer, rather than to utilize the services of wholesalers, jobbers, and brokers. This comes about with the growth of large scale industry and the standardization of product. Large establishments have the funds and volume of business which make possible the development of a complete producing and distributing machine within itself, while a small one does not. With standardized products salesmen are not so important. Consumers do not have to be made acquainted with the qualities of the product as is the case where there is a variety of competing goods which may serve the same purpose. People know what the standardized product is like. It may be the only one available for a particular purpose. Under such circumstances, there is not the great risk involved in producing and selling it, as in the case of novelties or of unstandardized products. Selling cost is less proportionately and the firm can undertake the marketing of the product itself.

With the growth of large-scale industry, the expansion of markets, the standardization of products and markets, the increase in the general knowledge of products on the part of the average person through advertising, the growth of mail order houses and of chain stores, the process of decreasing the number of middlemen is likely to continue with increased momentum as time goes on.

Agencies by means of which specialized industries are linked together. — Whatever views may be entertained about the reduction in the number of the middlemen, there can be no doubt as to the economic value of the agencies by which specialized plants, industries, and regions are linked together. First in importance come the transportation agencies, wagons and trucks, railroads, and steamship lines. The greater the specialization the more necessary are these agencies to convey goods from one stage to another in the process of transforming raw materials into finished goods. Banks and other financial institutions provide the necessary credit facilities; they lubricate, as it were, the machinery of exchange, and make it easier to work. Boards of trade and stock exchanges and auction houses supply convenient places where goods and securities can be bought and sold and contracts made for future deliveries. Insurance companies distribute the risks of wreck or fire or other misadventures. Other middlemen perform the technical services of centralizing, storing, dividing, packing, and otherwise preparing goods for the consumer. All of these and many other institutions have developed in modern industry hand in hand with the specialization which has taken place.

SUGGESTIVE QUESTIONS

1. " The middleman is a parasite who consumes without producing." Do you agree?
2. Is exchange productive?
3. Which of the various middlemen listed in the chart on egg produc-

tion (p. 563) do you think could be eliminated? Would it be possible for all eggs to be supplied by the farmers directly to the consumers?

4. Are the functions of the middleman eliminated when you buy an overcoat by mail " direct from the maker " ?

5. Explain why specialization in modern industry makes middlemen necessary.

6. Has the concentration of a continually larger proportion of the population in cities any bearing on the importance of storing? Has the multiplication of apartment houses any effect?

7. If your home were suddenly cut off from all contact with the outside world, how long could you live on the supplies stored there?

8. List some risks not mentioned in the text and tell how they are reduced or met.

9. Can you name any one whose business is that of risk-bearing? Describe the business.

10. Do any farmers with whom you are acquainted grade their eggs before sending them to market? Do they grade any of their other products?

11. What economic service is rendered by advertising?

12. Observe what proportion of the articles in a grocery store are packaged; in a drug store; in a book store; in a hardware store. What conclusions would you draw as to the character of the goods which are packaged?

13. Would you rather buy cookies in packages or in bulk? Why?

14. During the slack part of the day the grocer sometimes puts up sugar in five-pound lots. What function is he performing?

15. Do you think that there are too many middlemen? If you do, would you conclude that all middlemen should be eliminated?

16. Do you notice any tendency in your home town toward the elimination of middlemen?

BIBLIOGRAPHICAL NOTE

The books which deal only with this subject are too specialized to be of much value in this connection. The best material is found in texts which cover the general field of marketing and in periodicals on marketing.

Some of the best books to consult are P. D. Converse, *Marketing Methods and Policies* (New York, 2nd ed., 1924); F. E. Clark, *Principles of Marketing* (New York, 1922); and W. D. Moriarty, *The Economics of Marketing and Advertising* (New York, 1923). L. D. H. Weld, *The Marketing of Farm Products* (New York, 1916), is good on agricultural products. H. M. Clay, *Economics for the General Reader* (New York, 1918), has a condensed and systematic account. A better and more extended discussion is in A. Marshall, *Industry and Trade* (London, 1919). F. E. Clark, *Readings in Marketing* (New York, 1924) and Ivan Wright and C. E. Landon, *Readings in Marketing Principles* (New York, 1926), also contain a great deal of material on this subject and on that of the preceding chapter.

Good references on storage are A. L. Cricher, *The Merchandise Warehouse in Distribution* (Washington, 1925); H. B. Troyford, *Storing: its Economic Aspects and Proper Methods* (New York, 1918); and G. K. Holmes, *Cold Storage and Prices* (Washington, 1913).

CHAPTER XXXIX

THE GUIDANCE OF MODERN INDUSTRY

Who directs the industrial machine? — In an early chapter it was pointed out that modern industry, though carried on by specialists, each apparently working for his own ends, nevertheless succeeds in producing the goods which society wants in about the right amounts. To achieve a result of such gigantic magnitude and intricacy would seem to call for organizing ability of the highest order. And yet we have seen that this task is performed by the free action of men in pursuits of their own economic interests, guided by the prices prevailing in the markets. In order to produce goods of the kinds desired by consumers, and in just the needed amounts, it is necessary to apportion or distribute among the different industries the national resources of land, capital, labor, and directive skill in the correct proportions. This apportionment is largely spontaneous and automatic and is effected by the choices and decisions of millions of individuals, but it is not haphazard or purposeless. What then are the forces which direct these choices so that there is found a certain unity and harmony in the diverse activities of modern industry? It remains for this final chapter to summarize some of the forces which guide economic action and keep the industrial machine running smoothly.

Apportionment of productive resources. — The case of Robinson Crusoe has already been used to illustrate the order of human wants, and will serve again to illustrate the apportionment of economic resources for the purpose of gratifying these wants. Crusoe had practically unlimited land, a fair supply of capital in the form of guns, carpenters' tools, and similar things, the labor of his own hands, and a considerable amount of knowledge and organizing ability. His problem was how to apportion these resources so as to produce the goods which he needed in as large an amount as possible, of the best quality, and with the smallest expenditure of effort on his part and the least waste of his capital. His resources were first applied to providing himself with food and shelter; when these needs were met his activities were diverted into the making of furniture and clothing; at intervals they were applied to repairing and improving his equipment of tools and supplies. The problem was not a difficult one because Crusoe was able to see the entire situation, controlled all the factors of production, and could apportion them according to his own judgment. He sometimes made mistakes of judgment and devoted himself to one thing when he should have been working at another; but at least there was no friction.

The problem of apportionment which is faced to-day in our complex industrial society is very different. Here are many specialists producing goods for sale on a distant market instead of for their own consumption; each producer decides for himself what he shall produce and how much; various marketing agencies undertake the distribution and sale of the goods; and finally the consumer decides whether he will buy them. If there is an initial mistake in judgment on the part of the primary producer, or failure at any point along the line which carries the goods to the final consumer, there will result loss, waste of resources, and perhaps stoppage of the industrial machine. Each of the specialists in this long series of processes works on his own account, and there is no supreme directing will to guide and unite these varied activities or to decide how much capital and labor shall be devoted to one thing rather than to another, say to making automobiles as compared with building houses. A complete explanation cannot be given here, but must be sought in the study of the principles of economics. Some of the principal agencies and forces involved are, however, presented in the diagram on the following page.

Government action. — The apportionment of productive resources is effected in part by social and in part by individual action. By the former is meant the guidance or control exercised by groups, whether large or small, organized for political, social, or economic purposes, so far as these express themselves on questions of what shall be produced or consumed. The government — federal, state, or local — is the people organized for the expression of their will in the political domain, but in that capacity it controls production in many ways. In the first place, the government by its very existence diverts through taxation a considerable portion of the social income, which it then apportions to the payment of salaries, the maintenance of bureaus, the building of battle-

Apportionment of resources is affected by
- Social action through
  - Government
    - Taxing and spending
    - Operating industries
    - Encouraging
    - Prohibiting
    - Regulating
  - Social institutions
    - Tradition and inheritance
    - Imitation
    - Custom
    - Institutions or laws
  - Economic institutions
    - Personal freedom
    - Private property
    - Competition
- Individual action through
  - Desire for gain or other economic objective
    - Buying
    - Working
    - Owning and using
    - Investing

ships or irrigation systems, and many other things. Secondly, the government itself engages in production, operating water and electric light plants in many of our cities, and in European countries owning railroads, telegraph lines, and conducting various business enterprises.

More important, however, are the regulatory functions of government. Sometimes it encourages certain industries or lines of production: by a grant of a free homestead of 160 acres of land to any settler on the public domain it diverted a great deal of capital and labor into agriculture in the United States during the latter part of the nineteenth century; by granting a bounty on sugar at one time it stimulated the sugar industry; by protecting domestic industries through the tariff it diverts productive resources into these lines. On the other hand government sometimes prohibits certain industries, as the manufacture of intoxicating liquors, the sale of opium, and a few other things which are held to be undesirable. Most frequently, however, the action of government is regulatory and simply prescribes the conditions under which private industry shall be carried on; it lays down the rules of the game. Thus factory legislation prescribes the minimum age of child labor, the Interstate Commerce Commission fixes railroad rates, the city council condemns private land to be used as a park.

In these and many other ways government controls or influences the use of our productive resources, and decides what shall and what shall not be produced.

Social institutions. — Just as people organize themselves politically, so they organize themselves in various groups for the achievement of various social purposes. Such groups are the family, the church, the school, clubs and organizations for business, philanthropic, literary, athletic or other purposes. Through these institutions many social forces find expression and influence our choices in the expenditure of our incomes, or the choice of a job, or the use to which we shall put our resources. Among these forces may be mentioned tradition and inheritance, imitation, custom, and institutions.

The Post Office Department Building, Washington, D.C.

In this building are the offices of the Postmaster General and his assistants who are responsible for more than 50,000 post offices and more than 40,000 rural mail routes throughout the country.

Many ways of doing things have come down to us as a part of our social heritage and are accepted without much question as right and proper; they are traditional, and frequently determine our activities without regard to their reasonableness. The "right" way is the way our ancestors used. Thus in some countries it is not "right" to eat pork, to plow in the dark of the moon, to wear certain kinds of clothing. Other modes of action are determined by imitation; sometimes the imitation is of already accepted standards, as when a child imitates his parents, or the younger generation imitates the older one; sometimes the imitation is of new standards, such as occurs when a new fashion decrees a change in the style of dress. When certain modes of action have been followed a long time they become habitual or customary; we say that a certain method of doing things is " the usual way " or is " customary." Sometimes these customs harden into fixed institutions and are even given the sanction of law; control is now no longer traditional and unthinking, but is conscious and voluntary.

It is clear that our actions are governed by many forces and influences outside of ourselves, which reflect public opinion and belief. One has only to call to mind the numerous agencies which urge the building of internal waterways, or the granting of a bounty on the export of agricultural products, or the prohibition of the use of cigarettes, or other projects, to realize to what an extent social pressure determines economic actions. These help to determine our economic desires and activities, and thus to apportion our productive resources among various industries. This apportionment may be very different in different countries and at different times according to the changing social attitudes.

Economic institutions. — The most important group of institutions through which the social or collective will — if we may use such a term — finds expression in the apportionment of our productive resources, is economic institutions. Three of these may be described.

Personal freedom, liberty of the individual within the law, is a fundamental feature of modern industrial society. We believe that each man generally knows what is best for him and will use his freedom of choice to the best advantage; that by giving him a maximum of freedom the welfare of society will at the same time be promoted most. Accordingly, in modern industry a man is given not only social and religious liberty, but freedom to move, to choose his occupation, to associate with others, to produce and to trade, and to spend his income as he pleases.

A second economic institution which lies at the very basis of modern industry is private property. By this is meant the power of exclusive use or control or disposal over things. This right of ownership extends over movables and immovables, and even over intangible things like patents and copyrights. Such exclusive control is neither a God-given nor a natural right, but has been granted or sanctioned by society; private property may therefore be regarded as a social institution although its name indicates that it has significance only for the individual. It is believed that by giving to individuals exclusive control over the use or disposition of property they will utilize it to the best social advantage. The production of wealth will be carried on with superior energy, greater care in the use of tools, machinery, and plant, and less waste in raw materials or production than would be probable if ownership were vested in the state or in a group. The justification of private property rests upon the ground of social utility, because under this system more is produced than under any system of communal ownership yet tried.

The third economic institution is competition. This has been defined as " the act of seeking or endeavoring to gain what another is endeavoring to gain at the same time "; but this is only individual competition. There is also competition between commodities, between markets, and between countries; there is competition between producers, between sellers, and between buyers. In the sense in which it is used here, as economic competition, it is undoubtedly an organizing agency in our industrial society. " It assigns persons to their parts; determines what forms of organization shall survive; designates what ranges of industries and what plants within an industry shall come to the front; accounts for the rise and decline in economic importance of territories, cities, and markets; decides what technical processes and what marketing methods shall live; all this and more."[1] These things might be decided by inheritance and tradition, or by the authority of the state, but in modern industry competition is the organizing force. Competition is a selective process and through it we obtain the survival of the fittest.

It may seem as though the institutions of personal freedom, private property, and competition were individual forces rather than social, since they affect and operate through individuals. But they are institutions which have been adopted by society as part of the structure of modern industry; individuals carry on their economic activities under the conditions laid down by the existence of these concepts. We are justified therefore in thinking of them as socio-economic institutions controlling the apportionment of the productive resources of society.

Private initiative. — Although economic activities are sometimes carried out and frequently regulated by government, and are influenced by social and economic institutions, yet in the main we rely upon individual initiative to keep the machine running.

[1] L. C. Marshall, *Readings in Industrial Society* (Chicago, 1918), p. 885.

The apportionment of our productive resources to various industrial and other uses is determined for the most part by the free choice of individuals rather than by the dictates of government or by the pressure of social groups. Indeed, so important a part does the individual play that the modern industrial system is often called a system of individualism. By this is meant that each person is free to apply his labor or his land or his capital to any enterprise he pleases, and in return is free to obtain whatever share he can of the product, upon the basis of arrangements freely entered into with other persons.

Under this system we rely upon private initiative to produce the goods and services which we need. Every person is free to do as he wishes regarding the goods which he is to produce. No power designates directly what any person is to do nor whether he is to do anything. It is left entirely to the individual's self-interest to determine what and how much he shall produce. But he is not left entirely without guide or compass in reaching a decision. The guide which tells the individual to what purposes he can most profitably devote his productive resources is *price*. When the price of an article goes up, this indicates either that the demand has increased or that not enough was produced to meet the existing demand; in either case the producer is induced to increase his output and thus the needs of society are met automatically. On the other hand, if the price of an article falls, this shows that too much has been produced or that demand has declined; in either case the producer is warned against applying more labor or land or capital to that article, and is induced to devote them to something which will yield him a larger return, that is to those things which society wants more. It is assumed that price is thus an automatic indicator of wants, and that this, coupled with the desire for gain on the part of the producer, will bring about the best apportionment of the productive resources of society.

Self-interest as a motive. — Price may be the guide, but the desire for gain is the motive which determines the choices of countless individuals in the spending of their incomes and in the application of their labor or capital to production. As consumers we desire certain goods or services rather than others; our personal preferences determine the kinds of industries which shall be carried on and those which can not succeed. These desires or preferences are not altogether whimsical or accidental; they are affected by inheritance, social environment, and many factors outside of the individual, but they always find expression in the demand by consumers for goods in the market at certain prices.

As producers individuals also decide the kind of work which they wish to do, the kind of business or profession to which they prefer to devote their labor and their time. They also judge whether they wish to apply their land and their capital to one industry or to another, to the production of this article or that. In general, their decision is determined by the consideration of the greatest gain to themselves. They will apply labor and land and capital to those lines of production which will yield the largest return. Since these lines are the ones which produce goods most in demand by consumers, we may conclude that the motive of self-interest will lead men to direct the productive energies of society into the channels which will yield the greatest satisfaction. In other words, we assume that competition and private initiative lead to the best use of our social resources and will best harmonize individual advantage and social welfare.

Socialism. — This assumption has been severely criticized by the socialists, among others. They assert that the motive of self-interest leads not to social welfare, but to separation into classes, and to the domination of the weaker by the stronger. Private initiative leads to exploitation and monopoly; and competition results, not in the survival of the best, but of the shrewdest and most unscrupulous. Even personal freedom is not of itself a blessing, certainly not if it disregards the rights of others. The socialists especially attack the institution of private property, which, they say, has become the instrument of oppression and exploitation. Modern competitive industry is thus condemned by them on many counts.

What is needed, urge the socialists, is the ownership of the means of production and the guidance and direction of industry by the group instead of by the individual. They therefore wish to expand the functions of government and to diminish correspondingly the private initiative of individuals; to replace private property by public; and to substitute governmental authority for competition. There is not space here to explain socialism fully or to debate its aims; it is sufficient to point out that the guidance of industry and the apportionment of our productive resources might be determined by authority, whether this should be the will of a supreme dictator or the decision of a popular referendum. In either case the system would be vastly different from that which characterizes our modern individualistic competitive society.

Conclusion. — Would a system of authority be better than one of private initiative? Many books have been written on both sides of this question. This volume has attempted to describe the functioning of our existing system. Faults have been pointed out here and there, but on the whole it is evident that modern industry has been brought to a high point of technical perfection, and is steadily being improved. Needed goods are steadily produced, and the quality is generally being improved while costs are reduced. The productive resources of society are apportioned so as to produce an ever increasing amount of wealth. That some of this wealth takes on undesirable forms, that it is unequally distributed among the members of industrial society, and that sometimes the welfare of certain groups is sacrificed in the productive process — all of these criticisms are undeniably true. And yet it is believed that on the whole the present system yields better results than any other which has been tried or proposed. Desirable improvements could and should be made in the direction of greater attention to the welfare of the workers, to the elimination of waste of human and material resources, to improvements in the technique of marketing, and to the greater socialization of consumption and of wealth. Modern industry has greatly raised the material standard of living of the average worker; further improvement must build upon this solid foundation.

SUGGESTIVE QUESTIONS

1. Is the task of society, taken as a whole, essentially different from that of Crusoe in the apportionment of productive resources?

2. Would the problem of apportionment in modern society be simplified if it were entrusted to a single directing will instead of being decided, as at present, by many individual choices?

3. Explain how such a single directing will would be authorized and constituted. How would it arrive at correct decisions in the apportionment of labor, land, and capital to different industries? How would it know how much of various things to produce?

4. Would an extension of public industry secure a better apportionment of productive resources? Would it affect the amount produced?

5. Show in what way the church influences the apportionment of

productive resources; the school; a Chamber of Commerce; the Anti-Saloon League; the immigration restriction act; the tariff on raw wool.

6. Can you give instances of the effect upon the apportionment of productive resources of tradition? of imitation? of custom? of public opinion?

7. Do you think that the present complete freedom of choice of the individual is a good thing for the individual? for society?

8. The socialists say that the modern factory worker does not have freedom of choice, but that he is a "wage-slave." What do they mean by this?

9. Can you think of any ways in which the right of private property is curtailed? Would it be desirable to restrict it still further?

10. Explain more fully the statement, "competition is a selective process."

11. Show how partial reapportionment of productive resources would be occasioned by a decided fall in the price of cotton; by a doubling of the price of lumber.

12. A cotton mill in New Hampshire stands deserted; a summer hotel on a lake in Michigan is untenanted; a stock of goods remains unsold on a merchant's shelves. Would you say that in these cases a mistaken apportionment of productive resources had been made?

13. Do you agree that the desire for gain is the chief motive which determines economic choices and the apportionment of productive resources? What other motives exercise influence?

14. Define socialism, and explain how the apportionment of productive resources would be affected in a socialistic state.

15. Do you agree with the statements in the concluding paragraph?

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